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Joint Experimentation
Mini-Symposium and Workshop
8-11 March 1999
AFSC, Norfolk, VA

Chair
Dr. David S. Alberts

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101 South Whiting Street ♦ Suite 202 ♦ Alexandria Virginia 22304-3416
(703)751-7290 ♦ FAX: (703)751-8171 ♦ email: morsoffice@aol.com
URL: http://www.mors.org

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Table of Contents

Executive Summary

Background

The DoD has embarked upon an ambitious program of experimentation to support the transformation of the military to meet the 21st Century mission challenges. There is limited expertise and experience in designing, conducting and exploiting the results of large-scale experiments. The analytical community has much to offer but needs to adapt its methods, approaches and tools in order to support this program of Joint Experimentation. The goal of this special MORS meeting, attended by approximately 200 people, was to contribute to planning, conduct and exploitation of Joint Experimentation by leveraging the experience and expertise of the analytical community. The mini-symposium was designed to educate the DoD analytical community about the nature of military experimentation, recently completed events, experimental plans and the issues involved and future challenges. The workshop was designed to identify critical issues and develop conclusions and recommendations to improve Joint Experimentation. A unique aspect was the full participation of the US Atlantic Command (ACOM), the DoD's executive agent for Joint Experimentation. ACOM's participation helped ensure that the workshop focused upon issues of concern — and is expected to facilitate the adoption of the workshop's recommendations.

Mini-Symposium Synopsis

Given the diversity of the participants, the significant number of ongoing activities related to Service experimentation and the quickly moving program in Joint Experimentation, it was felt that the workshop needed to be preceded by a mini-symposium to bring participants up to speed and achieve a common level of understanding of the issues. Presentations by LTG Keane, DCINC, ACOM, and Maj Gen Peppe, J9, ACOM, acquainted participants with an overview of the goals and objectives of Joint Experimentation and current plans. Mr. Eash, DUSD (Advanced Concepts and Systems), provided information about the ACTD program. Mr. Starry, IDA JAWP, discussed the generation of concepts to be explored by Joint Experimentation. Dr. Alberts, (OASD(C3I)), discussed the nature of OR and challenges of Joint Experimentation. Three Service panels were convened. The first addressed Service Experimentation, the second, Service Laboratories and related activities, and the third addressed how the Services were structuring to work with ACOM on Joint Experimentation.

Workshop Organization

Workshop participants were organized into six working groups. A working group was assigned to each of the phases of experimentation: planning, design, preparation and conduct and analysis/exploitation of results. In addition, a working group looked at how modeling and simulation could contribute to each of these phases of experimentation. There was also a synthesis working group that looked for common findings across these working groups and provided an independent assessment of the major issues.

Major Findings

Nature of Joint Experimentation

The scale and complexity of Joint Experimentation currently envisioned presents its own set of challenges. These challenges are compounded by widespread cultural and organizational implications. With the goal of creating, nurturing and maturing innovative operational concepts and applications of technology, Joint Experimentation will, in order to be successful, require an unprecedented change to the status quo. This report will focus on only one dimension of change, the one that affects the way we plan, design, conduct and utilize the results of "experimental" campaigns and events. Change is required because the purpose and nature of experimentation is different from the purposes and natures of exercises, tests, evaluations and demonstrations that we are so used to conducting.

Joint Experimentation is an *iterative process* of collecting, developing, exploring and maturing *concepts* to identify, demonstrate and recommend *value-added solutions* for changes to DOTMLP (Doctrine, Organization, Training, Materiel, Leadership, and Personnel) to achieve *significant advances* in future joint operational capabilities. Discovery is an integral part of this process, as is the testing of hypotheses and the use of experimentation to demonstrate a capability. Given these different aspects of experimentation, the various community "cultures" brought to the Joint Experimentation table need to adapt new values, ideas and methods. Notions of what constitutes success and failure, the role of the assessor, the tradeoffs between free-play and control all need to be examined in a new light.

Central to the effective synthesis of on-going Service and Joint Experimentation into a coherent body of knowledge is the ability of all in the community to communicate effectively with one another. Differences in culture and language make this quite difficult. A common understanding of the nature of experimentation, the development of a new "experimental culture" and a universal lexicon of terms would go a long way to addressing these problems.

Turning Lessons Recorded into Lessons Learned

There is a growing body of "lessons recorded" coming out of Service experimentation. These lessons cover every phase and aspect of experimentation including the time it takes to plan, the process for screening experimental hypotheses and issues associated with conduct and assessment. Several "show stoppers" have been identified which alone can significantly degrade the utility of an experiment. Two key examples are: 1) failure to train the participants to an appropriate level of proficiency on either the systems or the concepts, or 2) failure to ensure that the experimental infrastructure (the systems) is properly functioning. Either of these failures can prevent the needed data collection, thus making the experimental results meaningless. In addition, many relatively small things can go wrong with an experiment. While any single one may not derail the train, the combination of many "duck bites" can seriously degrade the value of the experiment. Having at least a preliminary Code of Best Practice

(COBP) and access to lessons recorded during similar events could make a big difference in the outcome.

Leveraging Experimental Events

Particularly in the next few years, the Joint Experimentation Plan relies heavily on its ability to leverage a large number of Service events. Given resource and schedule constraints, the concept of leveraging is very attractive in theory. However, based on the military community's experience, it is very difficult in practice and the results are usually disappointing. To improve the chances of success, a number of important prerequisites must be satisfied. They include high-level agreements on objectives and priorities, written MOUs, integrated planning and conduct, deconfliction of scenario events and controllables and adequate resources and training.

Organize for Success

Given the iterative nature of experimentation and the complex interactions among design, conduct and assessment activities, it is critical to have a single integrated team stay with an experiment from concept to completion. The same is true for the development and maturation of a concept that involves synthesizing the results from many experimental events. It is recommended that the ACOM J9 consider reorganizing to accomplish this.

Need for Balanced Experimentation

It has been noted that many experiments have not achieved a proper balance among pre-experiment activities, the conduct of the experiment and post-experiment activities. As a result of insufficient resources being applied to the pre- and post- phases of experiments, experiments have not been as well focused, instrumented and/or executed as they could have been, and the data collected was not analyzed as thoroughly as it could have been. The bottom line is that there was a reduced ability to draw conclusions or reduced confidence in the conclusions that were drawn. Both pre- and post-experiment activities can contribute significantly to success by focusing on the interesting parts of scenario space and by performing "what if" and sensitivity analyses to leverage the limited observations obtained during the "live" part of the experiment. This is an extension of the model-test-model paradigm developed by the OT&E.

Balance is also needed across the functional components of experimentation. Insufficient resources and time given to training and assessment, for example, can seriously impair an experiment's ability to provide useful results.

Education and Training

Almost without exception there has not been adequate education and training for participants. All participants need to understand what the experiment is all about, what to expect, and how to be proficient in their assigned roles. This includes the users of experimental results, the director of the experiment, the players, controllers and assessors. Lack of education and training can be a real "show stopper." It is recommended that education and training be conducted and that levels of understanding and proficiency be assessed as adequate

before an experiment is allowed to proceed.

Planning

To ensure that experiments are successful, adequate attention needs to be paid to each of the following: concept development, concept exploration and refinement and the development of an experimental strategy. "Concept development" involves defining a statement of an idea expressing how something might be done that may eventually lead to an accepted procedure. Concept development begins with meta-analysis and matures through an iterative process employing OR tools. It makes assumptions in terms of environment, threat and timelines, and it determines, describes and defines the concept components in terms of DOTMLP implications, the continuum of military operations, the relationship to other concepts and the critical implications for change. "Concept exploration" expands and revises the concept based on iterative reviews and analysis. It can include seminars and workgroups and it typically decomposes components to identify/validate questions, issues and high-level performance measures. "Concept refinement" expands and iteratively revises the concept through limited objective experiments to resolve issues, and can include integrated simulation experiments and integrated field experiment(s). "Experimentation strategy" development expands and questions the issues that underpin the concept and prioritizes the focus for design of experiments and related events, and sets the scope and bounds of the design.

Preparation and Conduct

The key to successful execution is early identification and scoping of the objective of the experiment, related issues and hypotheses. J94 Operations Division is staffing a comprehensive cradle-to-grave task list for the preparation and conduct of joint experiments to address the following:

1. An objective review process that includes resource implications is essential for prioritizing issues and hypotheses.
2. Resources and timelines must be identified early on and be realistic.
3. Scenario development must accommodate the stated hypotheses and receive CINC approval and Services' buy in.
4. Senior leadership should be briefed early in the planning process on the objectives and scope of the experiment to right-size expectations.
5. In a model-exercise-model experiment, sufficient time must be provided for the pre- and post-exercise modeling activities.
6. Plans must be established for deployment and setup of the experiment infrastructure and its maintenance during execution, paying special attention to the care and feeding of experimenters, computers and communications.
7. Data collection requirements must be developed 6-9 months prior to the experiment in order to permit development of long lead-time instrumentation and automated collection tools.
8. Database development must be accomplished early by analysts and modelers working together.

9. An end-to-end pilot test of the supporting infrastructure to collect and process the data must be conducted before start of the experiment.
10. Sufficient time to conduct surveys and interviews of unit leadership must be coordinated early to ensure leader availability during and immediately after execution.
11. Visitor protocol should be established through a resourced visitor bureau to ensure proper treatment of VIPs and other visitors and to properly manage expectations of all concerned.
12. A hot-wash process during experiment execution must be established to provide adequate daily feedback to senior leadership and capture insights while fresh.
13. Analysis and reporting of the experiment should be conducted through post-event analysis workshops to include a wider analytic community in the final analysis.

Design of Experiments

Proper scoping and attention to managing the uncontrollable and confounding variables are the keys to success. The experimental design must focus upon the collection of the data necessary to support the objectives of the experiment whether they are discovery, hypothesis testing and/or demonstration. A Full spectrum Analysis employing Modeling techniques, tools and Experiments (FAME) needs to be utilized in the pre-experiment phase to focus the effort by identifying critical variables, the ranges of interest and the potential confounding effects as an input to the design process. Control is inherently difficult to achieve due to the large number of systems, processes and events that are an integral part of Joint Experiments. Statistical control techniques should be employed to mitigate this situation. The effects of learning need to be recognized and accounted for in the design of the experiment. The design of the experiment should explicitly consider the analyses that are to take place in the post-experiment phase so that small sample sizes can be "augmented" by analysis, model results and simulation runs.

Modeling and Simulation

A suite of models, including federations of models, needs to be brought to bear. Different models will be appropriate in each of the phases of an experiment. The current state of the art of modeling and simulation does not support the representation of ill-defined or understood processes (e.g., cognitive decision processes, chaotic behavior, information operations). Decision makers need to be educated on the limitations of modeling and simulation in general and on the assumptions and limitations of specific models so that they can better understand the results. In these cases modeling can be used to capture knowledge as it is developed and to express hypotheses. It is important that the right model be selected for a particular task. Explicit selection criteria should be developed and employed for this purpose. The need for model credibility is a driver in the selection of which model(s) to use. Currently it is difficult to gain Joint acceptance for a model developed in one Service. It is important that we develop a joint approach for validating models that

represent the future for use in Joint Experimentation.

Assessment and Utilization of Results

The value of an experiment depends, in large measure, upon the technical quality of the assessment, the credibility of the assessment process and the "actionability" of its results. A quality control process with "checks and balances" is needed to ensure quality. Experiments are not tests and a distinction needs to be made between assessment with a small "a" and assessment with a large "A." The former being an "enterprise" approach to assessment that is appropriate for experimentation vice the latter "independent test" mindset. In the small "a" approach the assessment team is fully integrated into the experimental planning, design and conduct. Given the importance of assessment to the overall Joint Experimentation process, adequate time and resources are needed to get the most out of each experiment and results need to be documented in a way that facilitates their utilization. An important aspect of assessment is the ability to produce very rapid feedback concerning progress on experimental objectives. To ensure that the need for speed does not degrade the quality of any "quick-look" assessment, the assessment team must develop a plan and a capability for accomplishing timely preliminary assessments and to educate decision makers and participants regarding the caveats associated with these preliminary assessments. A "spiral" assessment process is recommended that tailors assessment activities to the various stages of experimentation (e.g., discovery, hypothesis testing, demonstrations). This will ensure that appropriate methods and tools used as a concept are taken from the initial formulation and are explored, refined and matured to the point where they can become a fielded operational capability.

The Way Ahead

We have concluded that experimentation (and especially large-scale experimentation) is an essential element of any strategy to transform the DoD into a relevant and capable 21st century force. Experimentation is a valid construct. If it is done well, the results will be more effective mission capability packages that leverage information superiority to achieve JV2010. Doing it well will require that adequate attention is paid to assessment and validation of results. Experimentation on this scale is new to the DoD. It is not without its risks, but the workshop concluded that these risks are far outweighted by the potential of experimentation to bring out the best in new and emerging concepts, and to expedite the fielding of significantly improved capabilities. The pace of technological change mandates that DoD embrace new methods to move forward, and early activity suggests that we are on the right track and should hold the course.

Joint Experimentation Workshop

Design of Experiments WG

Design of Experiments (DoE)

Working Group Participants

Bob Sheldon	*S3I*	*MAJ Mark Lee*	*TRAC-Lee*
Daniel Serfaty	*Aptima, Inc*	*Tom Lucas*	*NPS*
FT Case	*JHU/APL*	*Kendra Moore*	*ALPHATECH*
Gary Coe	*IDA*	*Cindy Noble*	*TRAC*
Tom Connors	*SYNERGY, Inc.*	*Bob Peterman*	*AF Exp. Office*
LTC Pete Davidson	*Army OPTEC*	*Isaac Porche*	*RAND*
Paul Davis	*RAND*	*Bob Powers*	*SAIC*
Elliot Entin	*ALPHATECH*	*Roger Pratt*	*SM&A Corp.*
MAJ Steve Forsythe	*AFSAA*	*Roy Rice*	*TBE*
Patrick Gorman	*BAH*	*Cy Staniec*	*Logicon*
John Gray	*AB Tech, Inc.*	*LTC Frank Zawada*	*AFRL/VSSW*
COL Jack Jackson	*IDA/JAWP*	*Dick Hayes*	*EBR*
CAPT Aaron Johnson	*ACOM*	*Clayton Thomas, FS*	*AFSAA*
LTC Jack Kloeber	*AFIT*		

WG Chair: Bob Sheldon

WG Co-chair: Daniel Serfaty

ACOM Representative: CAPT Aaron Johnson

Synthesis Group Members: Dick Hayes and Clayton Thomas, FS

The WG consisted of DoE statistical experts, representatives from academia (AFIT and NPS), senior military operations research analysts, as well as analysts with experience in large service field experiments.

Design of Experiments (DoE)

Key Issues and Questions

Concept Experimentation Strategy

- *DoE → Campaign Design, Not Event Design*
- *What is a Good Campaign Design (in the Joint Context)?*
  - *Control vs. realism of experiment*
  - *Full-Spectrum Analysis, Modeling and Experimentation (FAME): covers solution space*
- *How do we conduct FAME?*
  - *Continuous design incorporating M-T-M-T-M...*
  - *Hierarchy or ladder of Issues-Decision-Arguments-Hypotheses-Experiments-Measures*

DoE is really a campaign design, not just an event design. So, what constitutes a good campaign design in the Joint context? We know what a good experimental design is...however, in the joint context (i.e., field exercise events), obtaining a good experimental design (e.g., randomized, orthogonal, factorial design) may not be feasible. So, what does a good design mean in this context? And, how do we obtain a good design?

We place an emphasis on Full-spectrum Analysis, Modeling and Experimentation (FAME). FAME is the complete set of experiments (wargames, discussions, seminars, constructive/ virtual/ live simulations, analytic models, ...), both before and after the field experiment (the "event"). In other words, it IS the Campaign. Design is not locked up-front, but evolving.

The campaign design should flow from the issues (a shortfall in capability), which lead to the Decisions that need to be made (purchase technology X, implement CONOPS Y). These Decisions will be based on arguments (what is needed to make the decision, what is in dispute). The arguments should be used to generate hypotheses about something unknown (technology X provides improved capability); these hypotheses lead to experiments which confirm, reject or enable us to refine the hypotheses based on some measure (MOP, MOE).

One thing we need to avoid is unwarranted enthusiasm for the event results.

Design of Experiments (DoE)
Lessons Learned From Large Field Experiments (1 of 2)

- ***Field events do not replace operational testing requirements***
  - ***Large numbers of systems***
  - ***Large number of uncontrolled variables***
  - ***Small sample sizes***
- ***Late arriving issues / initiatives to field events do not allow adequate training and skew data collection***
- ***A Review Process is needed to preclude immature experimental systems; balanced with development timelines having realistic risk assessments***
- ***Conduct at least one complete end-to-end rehearsal***
- ***Only one organization to collect and process data***

There are many relevant lessons learned from service warfighting experiments that apply to Joint Experimentation.

Experiments provide early user input on mature technologies, but do not replace operational testing. The large number of systems involved in the experiment does not allow identification of the individual system contribution. They also provide a large number of uncontrolled variables such as weather, terrain, leader decisions, force mix, etc. The limited number of iterations does not provide sufficient iterations to determine suitability. "Credit" must be allowed for the data collected during experiments to reduce future test costs.

Late arriving issues/initiatives do not allow adequate training and skew collected data. In order to collect valid data, personnel involved must be trained to effectively employ the issues/initiatives. Adequate MOE/MOPs and instrumentation must be in place to effectively collect and evaluate the issue/initiatives. If Subject Matter Experts (SME) are employed to collect qualitative data, they must be tasked, trained and effectively positioned to provide the insights necessary to evaluate the issue/initiative.

A rigorous "Experiment Review" process is needed to preclude immature experimental systems; balanced with development timelines having realistic risk assessments. Immature systems require extensive contractor support to keep them operational or must involve significant simulation. These technologies disperse the data collection and analysis efforts. As planning for the large field experiment progresses, systems not meeting their developmental timelines need to be dropped and efforts concentrated on the more mature technologies.

To insure a successful experiment, at least one complete end-to-end rehearsal must be conducted including the actual player units, full up data collection and analysis. While, the rehearsal might not have the same duration as the experiment, the rehearsal must walk through every aspect of data collection and analysis. The unit must be comfortable with the instrumentation, data collectors and SMEs. The unit must be evaluated for adequate training on all issues and initiatives; data management plans finalized; and MOE/MOPs validated.

The experiment must achieve unity of data collection. The unit must deal with only one organization that will collect and process data. The analysts need one point of contact to optimize data elements to insure adequate data is collected. The data management organization must optimize the data collection plan to provide the analysts with the most data with minimal disruption of unit operations. The data collection organization will deliver the analysts one consolidated database.

Design of Experiments (DoE)
Lessons Learned From Large Field Experiments (2 of 2)

- ***Big Event orientation constrains derived value***
- ***Archive raw data for future experiments***
- ***Must have common language. Define experiment, demonstration...***
- ***Need both quantitative and qualitative data to conduct full spectrum analysis***
- ***Analysis of field events should be based on mission completion, not time lines. Time should be allowed for unanticipated complications.***

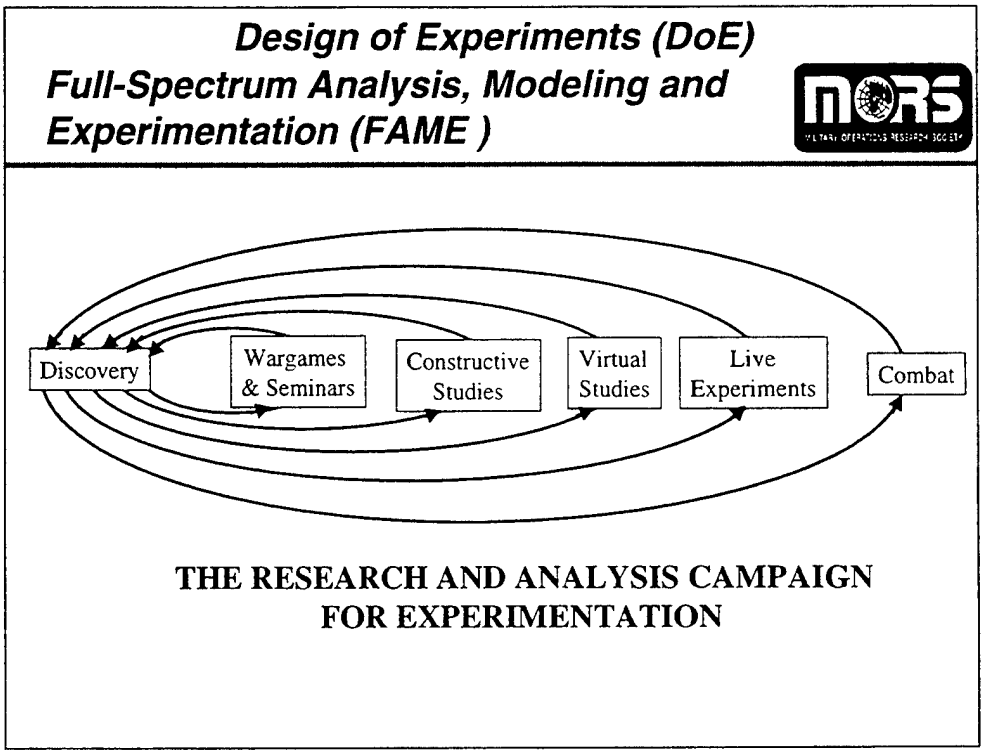
Optimal experimentation requires small, coordinated, well-focused events, but cost forces consolidation. Smaller experiments will minimize the deficiencies previously mentioned, but experiments must have enough control to insure valid data. Leveraging numerous events without control wastes time and money. Too much consolidation makes analysis extremely difficult. Therefore, experimentation is optimized on cost to get the most data for the dollar.

All services must develop a method to archive raw data for future experiments. Once the final report is written, most participants, including civilians, move on to other tasks and the data is lost. This data was collected at great expense and needs to be retained for future use. Testers can leverage the experiment data to save money. Program managers can analyze the data to improve the equipment over time. In a series of experiments, a trend can be identified if the data is available.

As more joint experiments are conducted, the services must have common language. Currently, each service defines experiment, demonstration, etc., a different way. Each definition means a different level of data collection and analysis effort as well as realism. In order to coordinate efforts and communicate findings, a common language needs to be developed.

To conduct full spectrum analysis, analysts need both quantitative and qualitative data. Quantitative data will tell the analysts and decision maker that something happened, but qualitative data is required to explain why it happened. This is especially critical in most C4 initiatives as information is used differently by each decision maker.

Analysis of field events should be based on mission completion, not timelines. Models crash and cannot support a command post exercise. Weather prevents missions from being accomplished. The data must still be collected to effectively analyze issues/initiative. Redundant events should be scheduled during the experiment to insure adequate data at the end of the experiment. Status of the data collection plan must be monitored daily to insure all the data requirements are met at the end of the experiment. If a certain data element is not going to be collected, risk assessment must be conducted to determine if the experiment must be changed to insure the appropriate data is collected. Time must be allowed in the schedule for unanticipated complications.

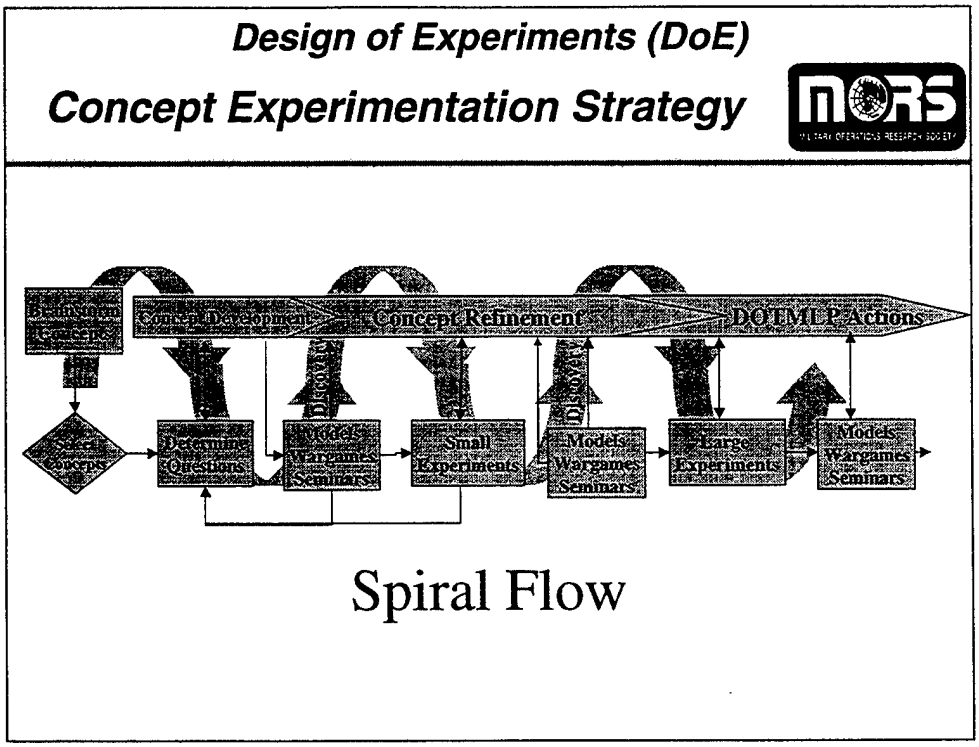


Joint Experimentation should be seen as a campaign of events that uses different environments and tools as a process for understanding or discovery of knowledge about questions relating to decisions that will be made. Although the campaign will be conducted differently for each experiment, we might expect to initiate concept development through wargames, seminars or discussions to define first abstractions and identify initial issues.

As the concept takes form, a concept model should be defined that describes the processes, equipment, organization, procedures and information flow initially required. As dynamic issues are identified, the campaign might move into studies that are based on constructive simulations. Such simulations are useful in examining physics-based phenomena in which mathematical relationships are known. They can run literally millions of iterations allowing the investigation of phenomena under the variance of selected variables. Constructive simulations can also be used to explore process definitions and flows and to help bound the decision space for virtual and live experiments.

Some issues, particularly those involving human performance are so complex that they are not amenable to constructive studies; in these cases, we need to employ human-in-the-loop methodologies. Virtual studies are particularly important for examining system integration issues where decisions are integral to the effective functioning of systems. Also, there are other issues that require investigation of a concept in a field situation. These include larger integration issues (e.g., the integration of large organization) and issues of stress and realism that cannot be replicated in a constructive simulation environment.

Different environments and tools of varying fidelity are needed because no one tool or environment has all the attributes required to answer all the questions required for a successful experiment. Resource and safety constraints are driving factors in using a campaign rather than a single environment.



Experimentation design is a continuous process that should begin with concept selection by the warfighting sponsor. The concepts are winnowed down to a select few that can be experimented with. Once we identify the concept to study, we can determine key warfighter questions that must be answered. Then the experiment can be designed (i.e., hypotheses, variables, resources, etc.) around these questions, taking assessment, integration and training into account including the objectives of numerous supporting experiments. An execution plan for each supporting experiment must be developed which may be a seminar, wargame, and constructed or virtual model.

"Red Teaming" is a critical aspect of the execution plan.

To react to experimental discovery, the plan or the concept itself must be revisited after completion of each supporting experiment to ensure proper coverage of warfighters' questions and feasibility of continued experimentation. The designs of small and large field experiments must draw upon results of the earlier experiments. The field experiments, combined with earlier experimental results, lead to action, more discovery and further experimentation.

The spiral continues until the warfighters' questions have been sufficiently answered — i.e. the main concept has been accepted or rejected. DOTMLP actions must be assigned to implement recommended changes based upon the experimental results.

Design of Experiments (DoE)

Recommendations (1 of 2)

- *Focus on Campaign Plan for Research and Analysis, not just Field Experiments*
- *Campaign Plan Informed by Sense of Potential Decisions* "Model" must include: Human Wargames, ...
- *Emphasize Model-Test-Model (M-T-M-T-M...)*
  - *Assure coverage of "scenario space" and "technical/operational issue space"*
  - *Big field tests used for integration, gathering special hard-to-get knowledge, and demonstration*
- *Use FAME*
- *Use Red Teaming throughout*

Develop a campaign plan informed by a sense of potential decisions (e.g., regarding feasibility and desired nature of a very-rapid JTF capability).

- Research relevant studies, operational training data, etc., to focus or structure hypotheses.
- Emphasize Model-Test-Model (M-T-M) paradigm that assures coverage of "scenario space" and "technical/operational issue space," with big field tests used for integration, gathering special hard-to-get knowledge and demonstration.
- For M-T-M to be real, treat BOGSATs, map games, etc., as "models"; achieve this by structuring the insights gained from these techniques. M-T-M with only standard constructive models would omit key sources of innovation (e.g., the human-in-the-loop).
- Full-spectrum Analysis, Modeling and Experimentation (FAME). The purpose of analysis and modeling is to gain, record and transmit knowledge about the full space, not just to prepare for and exploit field experiments.
- Red Teaming is an integral part of the entire process.
- Plan to assure having, for "constructive" models:
  - Multi resolution model families — from closed-form models, spreadsheets, through entity-level simulation
  - Interactive modes to assure innovation and red teaming
  - Decision and behavior models to represent alternative human actions seen in interactive work and field experiments.
- For analysis, plan to assure having:
  - Exploratory analysis in breadth (across scenario space)
  - In-depth analysis where most needed
  - Analysis to inform improvement of higher-level constructive models based on hires work and field experiments, and vice versa.

Design of Experiments (DoE)

Recommendations (2 of 2)

- *Assessment and Design Groups Must Work Together*
  - *Campaign design requires more then forward linkage to assessment*
- *Seek Top-to-Bottom Motivation and Coherence*
  - *Hierarchical operational objectives*
  - *Hierarchical functional objectives*
- *Training: Integral Part of Campaign Design*
  - *Subjects need training for unbiased results*
  - *Types: task, technology, procedure, team*

- Campaign design requires more than linkage to experiment assessment. We need to actively close the loop on the M-T-M paradigm, i.e., we need to fold the results back into the model.
- Seek top-to-bottom motivation and coherence.
  - Hierarchical operational objectives:
    - Starting with DoD-specified operational challenges (e.g., early halt or effective intervention in a 1991-Bosnia-like situation);
    - Continuing with subordinate operational challenges, recursively (e.g., establishing immediate theater C2, C4ISR, missile defense…)
  - Hierarchical functional objectives:
    - Starting with, e.g., global command and control architecture
    - Continuing recursively with subordinates (e.g., worldwide comm suitable for all classes of military operations)
- Training is necessary for the experiment participants to include task, technology, procedure and team training. This is required to provide accurate results from the experiment and ensure relevant feedback from the participants.

BACKUPS

Design of Experiments (DoE)

Agenda

- Tuesday, 9 March 1999, 1330-1700
  - Introductory comments
  - Presentation/ discussion
    - Paul Davis, RAND
    - Gary Coe, IDA/JAWP
- Wednesday, 10 March 1999, 0800-1200
  - Presentation/ discussion
    - Tom Lucas, NPS
    - LTC Pete Davidson, OPTEC
- Wednesday, 10 March 1999, 1300-1700
  - Presentation/ discussion
    - Daniel Serfaty, Aptima
    - Col. Jack Jackson, IDA/JAWP
- Thursday, 11 March 1999, 0800-1200
  - Presentation/ discussion (includes preparing outbrief slides)

Slides for most of the briefings are provided in the appendix.

Design of Experiments (DoE)

Suitability Matrix

Environment	Example	Detail & Fidelity	Human Elements	Sample Size	Control	Adaptability
Wargames /Seminars	Global		Y		Y	G
Non-interactive Model	CAST-FOREM	Y	Y	G	G	
Interactive	JANUS	Y	Y	Y	Y	
Virtual	STOW	G	Y		Y	G
Live	NTC		G			G
Combat	Desert Storm	G	G	Y		

ATTRIBUTES OF EXPERIMENTATION ENVIRONMENTS

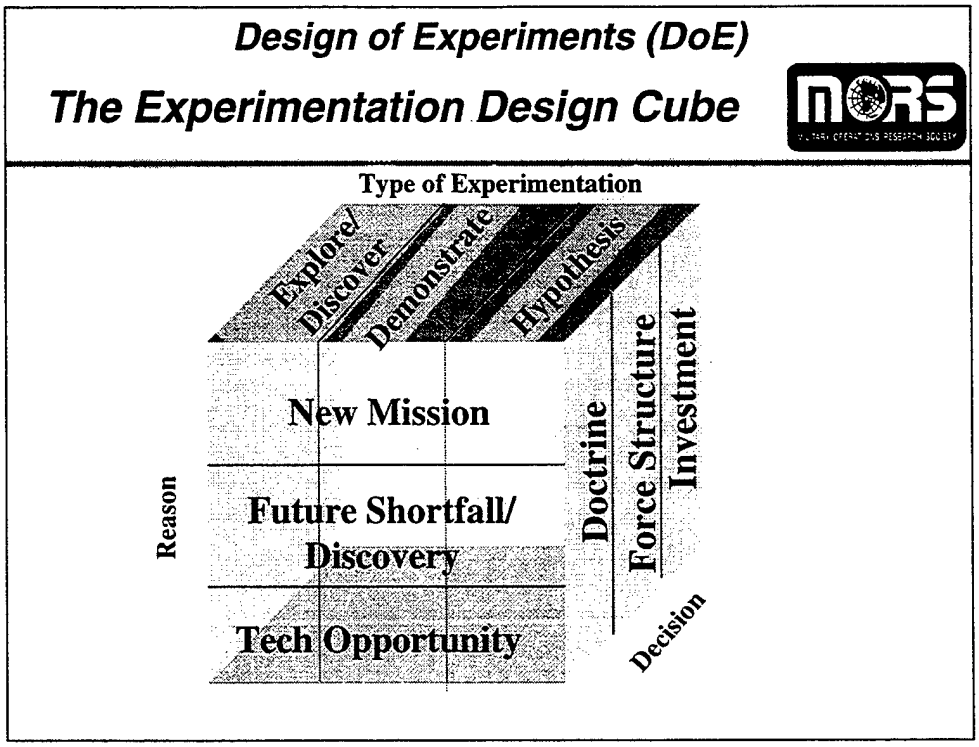
Joint Experiments cannot be conducted in one environment using one tool; rather a broad array of environments and tools are required for successful experimentation.

Hypothesis adjudication is a challenging task because no combat model can be presumed to accurately predict the outcomes of real combat. Indeed, due to safety restrictions and lack of knowledge of future threats, even live simulations must be regarded as, at best, weakly predictive. Here is a framework for understanding how to use weakly predictive models for quantitative/ qualitative insights to help design analysis to adjudicate hypotheses. In general, hypothesis adjudication will require that different experiments be conducted in different environments.

This matrix displays the strengths and weaknesses of several attributes of experimentation environments. Green cells indicate that the environment (row) has good capability related to the attribute (column). Yellow and red cells represent moderate and poor capabilities. This matrix is an example of how to view a sample of attributes of various environments and it is not intended to represent the full spectrum of possibilities.

Most events do not formally include non-interactive constructive models. Exclusion of non-interactive constructive models severely restricts the ability to perform many experiments, examine the effects of many different variables and scenarios, control of nuisance factor, manipulate stimuli and replicate results. Moreover, as constructive simulations are less dependent on the training proficiency of the solders as well as unreliable (as least, not fully tested) hardware and software, they are well suited to compensate for some of the problems introduced by training.

The explicit use of relatively inexpensive environments (wargames, seminars and constructive simulations) (as compared to virtual and live simulations) should be considered to supplement the other test environments to strengthen the adjudication of concept hypotheses.

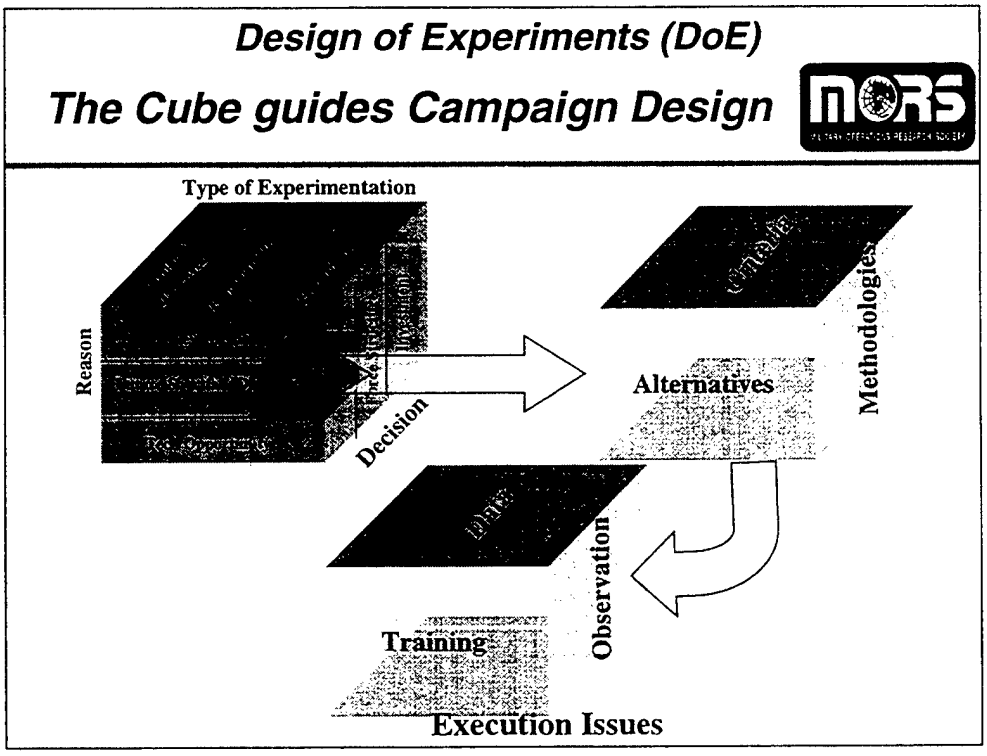


The REASON (front face of cube) for developing any new concept and entering into an experiment can be categorized as either attempting to (1) satisfy a New Mission, (2) alleviate a known Future Shortfall in capability — or discover if one exists, or (3) examine the introduction of a Technological Opportunity.

The types of experimentation (top face of cube) that we conduct fall into one of the three categories shown. They are to: (a) Explore or discover; (b) Demonstrate a capability; or, (c) test a proposed Hypothesis.

Finally, there are decisions to be made based on the outcome of the types of experiments being conducted for the purposes of examining the concepts. These decisions are shown on the side face of the cube as either (I) Doctrinal decisions, (II) Force structure decisions or (III) Investment decisions.

This taxonomy divides the large cube into 27 sub-cubes (some of which may not be populated). An example might be New Mission-Demonstrate-Force Structure. This sub-cube would dictate that a force structure decision is to be made as a result of a demonstration of a capability that will fulfill a new mission. We must now further decompose this sub-cube as seen in the next slide.



We must extract this sub-cube and look at its dimensions. Based on the Reason, Type of Experimentation and the Decision to be made, we must structure our Experiment and the subsequent analysis around the Alternatives (front face of upper right sub-cube), Criteria (top face of upper right sub-cube) and Methodologies (side face of sub-cube). This means that the range and types of *alternatives* we examine in the experiment are highly dependent on the three factors of the large cube. Once the alternatives have been established, the analysts determine the appropriate *criteria* necessary to distinguish among the alternatives. Given these criteria, the analyst finally determines the analysis *methodologies* required to calculate or quantify the criteria.

Now, we must think of a further decomposition into a sub-sub-cube. This is represented in the cube at the bottom of the chart. Once the analyst determines specific alternatives, specific criteria and specific methodologies, that sub-sub-cube generates a taxonomy of Execution Issues. These are shown to be Training, Data and Observation. The experimentation planner and analyst must adequately plan for training the participants in the use of each alternative (e.g., a new system to be used in the field). They must also plan for and execute the data collection, which may be peculiar to the methodology and criteria. And finally, the experimenter and analyst must plan for and properly execute the observation function, which will depend on the data being gathered and the training that was provided for.

This taxonomy of cubes and sub-cubes is meant to highlight the complexity of the Joint Experimentation Process. Many times in the discussions our Working Group had, we would be talking about one dimension, then someone would suddenly take the discussion into another dimension (another cube or cube face), then we would either jump back to the original dimension or off to another. We must understand the dimension we are dealing with in our discussions.

Joint Experimentation Workshop

Planning Experiments Working Group

Planning Experiments Work Group

Agenda

- Participants
- Joint/Service Experimentation Integration
- Exploration Cycle
- Concept Development
- OR Contributions
- Process for Realizing a Concept
- Resource and Infrastructure Considerations
- Interesting Things Discussed
- Issues and Observations

Planning is the most critical piece of any experiment from an analytic standpoint. Planning sets the framework for what can and cannot be accomplished analytically to assist decision makers with critical decisions. The steps identified in this agenda will help establish a well structured planning process.

Planning Experiments Work Group

Work Group Participants (1 of 2)

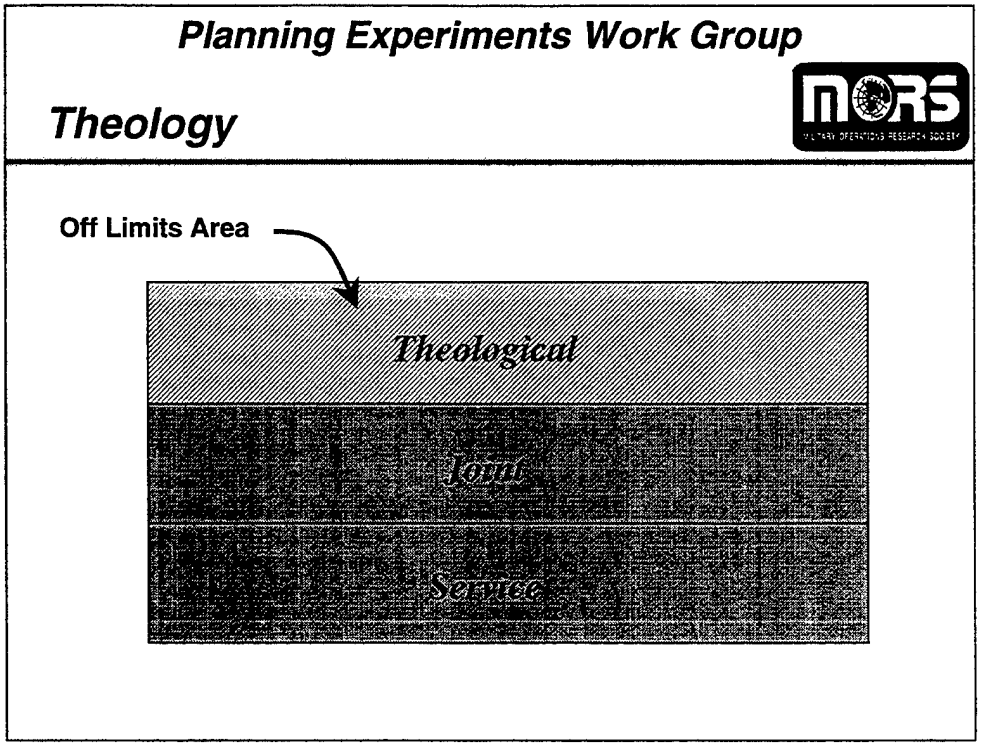
• COL Steven Myer	TRAC	Chair
• COL Rod Reay	AFOTEC/OL-VA	Co-Chair
• Mr Ed Ashley	SAIC	
• Mr Grant Ayres	USACOM J92	
• Mr Joe Bonnet	SETA/Joint Staff, J-8-LLWAD	
• Mr Mike Borowski	MITRE/JT&E Program Office	
• Mr Carl Cafiero	SYNERGY Inc.	
• Mr Bernard Ferguson	JT&E PMO Support/SAIC	
• Mr Bob French	AF Experimentation Office	
• Mr Jerry Horton	EDO	
• Mr Dave Ingle	JBC/SAIC	

Participants in the Planning Experiments Work Group brought a wide range of experience in experimentation and analysis to our discussions.

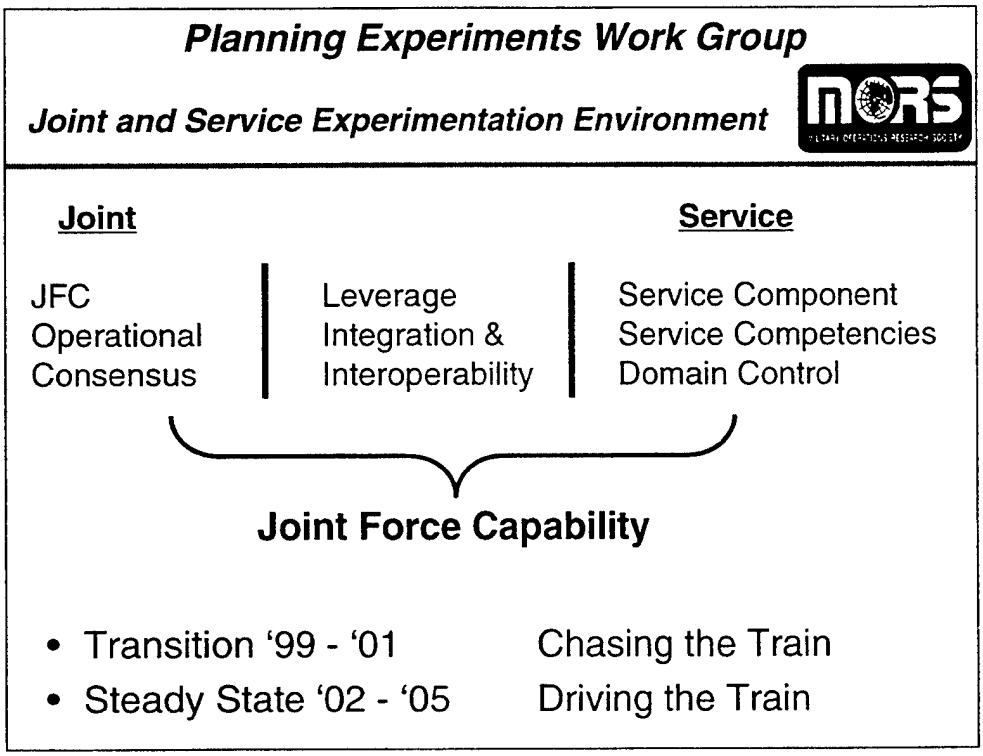
Planning Experiments Work Group

Work Group Participants (2 of 2)

• Mr Joe Jackson	MITRE/USACOM
• Mr Joe Jennings	MITRE/USACOM J9
• Mr Frank Mahncke	JWAC
• Mr Bill McDonald	SPARTA Inc.
• Dr Jimmie McEver	RAND
• Mr Jack Moffatt	AF Experimentation Office
• MAJ Tim Moore	AF Experimentation Office
• MAJ Robbie Mosley	OASD (C3I)
• Dr Russell Richards	MITRE/USACOM J9
• Mr Chuck Walters	JT&E Program Office (OSD)
• Dr Robert Worley	IDA

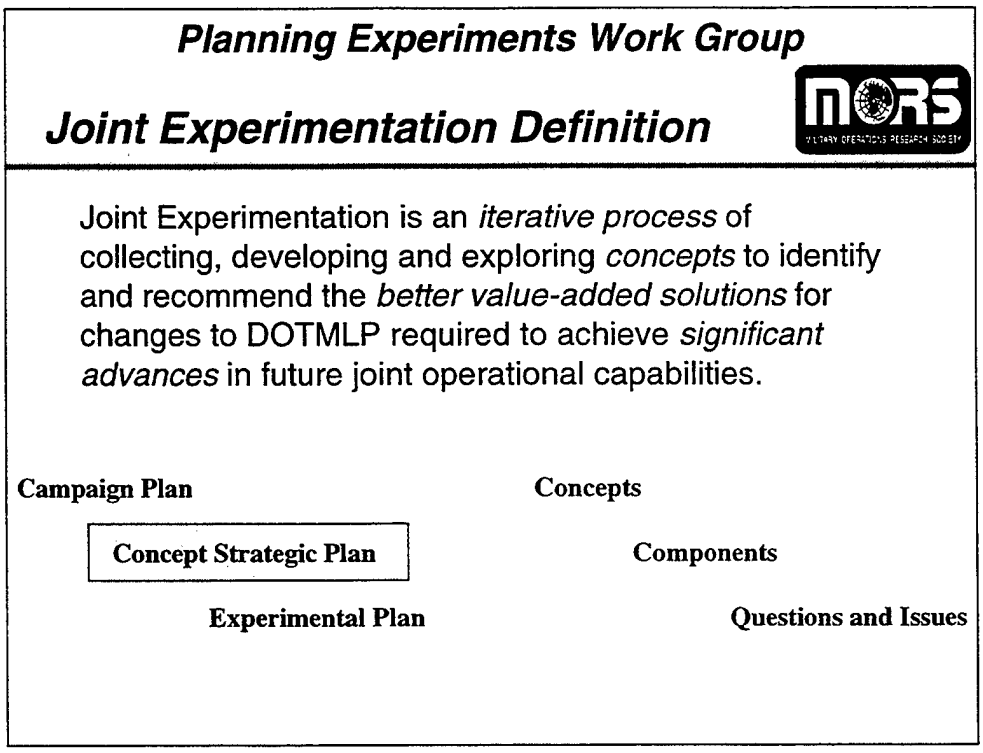


Our work group tried to stay out of the theological area of discussions, although at times we were unsuccessful. We focused on the linkage required between service experiments and joint experiments. This planning process assumes that Joint Experimentation will leverage existing service activities for the near term.



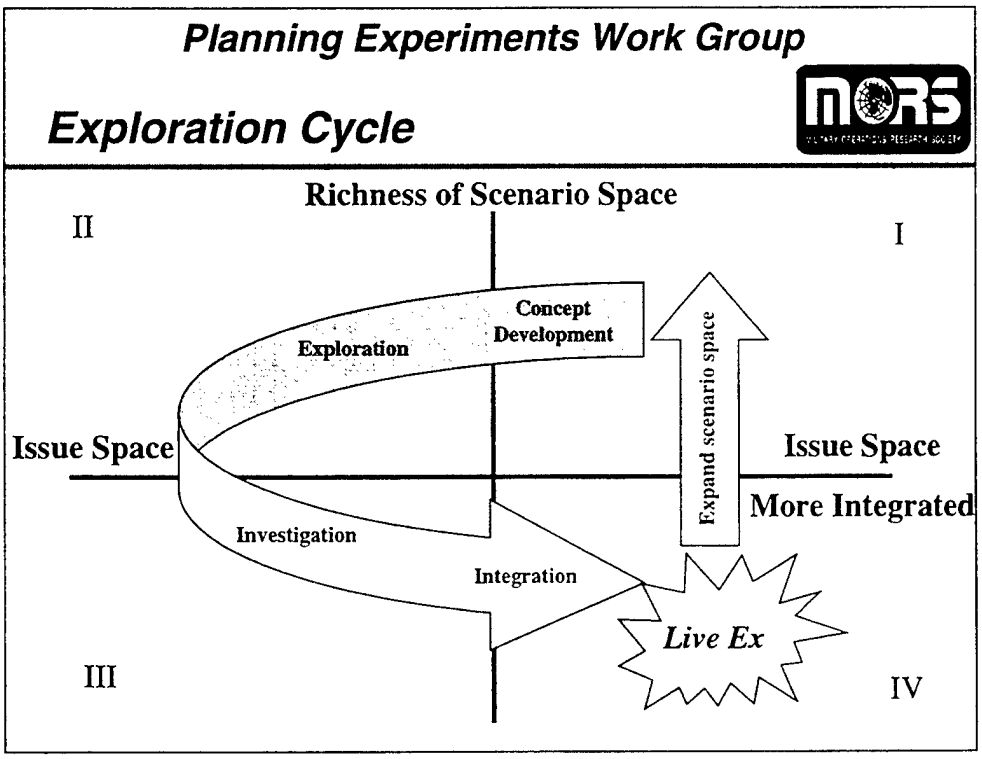
Our group dealt at length with determining the overall objective of joint experimentation in relation to service experimentation. This chart depicts Joint Experimentation as focused on the Joint Force Commander and operational level issues conducted through a consensus process. Service experimentation as focused on Service competencies in warfighting with Title X domain control. Between the two are leveraged experimental opportunities that have particular attractiveness in terms of joint interoperability. Together these combined experimental efforts should enhance the Joint Force Capability. The point is to properly position and combine the two for the greatest benefit.

Additionally, as we plan experimentation, we have to leverage existing events in the short term ('99-01) and present targets and issues of opportunities for the Services to support in the steady state ('02-'05).



Experimentation is a process, not an event. It is an iterative process that continually develops and explores concepts through a campaign plan. A Campaign Plan consists of numerous Concept Strategic Plans that occur during a designated timeframe. Campaign planning is synchronization among concepts to get the most out of questions that need to be answered and to leverage resources. The Concept Strategic Plan, which is part of the Campaign Plan, decomposes concepts into components which can be explored to further mature a concept. The Experimental Plan is developed to identify the relevant/ key questions and issues to be answered. There may be several Experimental Plans for a single concept.

The Planning Experiments Working Group focused on the Concept Strategic Plan.



There has been a tendency in experimentation to move directly from concept development to large scale/live experimentation. (Quad I to Quad IV). This slide depicts a way of envisioning the maturing of a concept from definition to validation through "issue and scenario space." In Quad I the concept is defined and developed in a rich scenario space with all the potential issues that compose the concept. In Quad II the concept is explored in many scenarios with a refined set of issues. In Quad III the critical issues that comprise the concept are more rigorously investigated in a limited set of scenarios to establish causal relationships, implications, etc. In Quad IV the issues that make up the concept are integrated and validated in a rich environment that reveals the 2nd and 3rd order effects of the various dynamics in the concept. Finally, the mature concept is modeled/investigated constructively in additional scenarios (back to Quad I).

This is an iterative process where concepts return to the initial stages of development if not mature enough to continue. Keys to this process are well thought out decision criteria/ decision points to proceed to the next level.

Planning Experiments Work Group

Concepts

- **Definition**: Notion or statement of an idea expressing how something might be done or accomplished that may lead to an accepted procedure
- **Development**
  - Meta-analysis
  - Iterative process
  - Assumptions
  - Concept components and interaction across DOTMLP and continuum of military operations
- **Refinement/Exploration**
  - Expand and revise **ITERATIVELY**
  - **DECOMPOSITION** of concept components
- **Experimentation Strategy**
  - Questions/ Issues that underpin the concept
  - Focus for design of experiments/ events
  - Scope/ Bound for design

A concept begins with a notion or statement. It is developed to determine, describe and define the concept components in terms of DOTMLP implications, the continuum of military operations, relationships to other concepts and critical implications for change. It begins with a Meta-analysis and matures through an iterative process. Assumptions in terms of the environment, threat and timelines are developed.

It is refined through exploration (seminars, workgroups, etc.) and is expanded and revised based on iterative reviews and analysis. Concepts are decomposed into components to identify/ verify questions, issues and upper level performance measures.

An experimentation strategy is developed to provide the focus in order to design an experiment or event. It identifies the key questions required to underpin the concept and provide the answers which will inform the validity and/or value added of a concept. The experimentation strategy provides the scope and bounds of an experiment in terms of DOTMLP, the continuum of military operations, component capabilities, areas of greatest potential and the baseline.

Planning Experiments Work Group

OR Management Tools

- Baseline Assessment Database
- Concept Hierarchy Tool
- Events Database
- Issue Integration
- Task Analysis
- Concept Prioritization/ Cost Benefit

In addition to the Operations Research (OR) tools and techniques that are available for experimentation, there are other tools to manage the experimentation process and experimentation campaign itself. J9 has already developed a suite of applicable tools to do this as listed in this slide.

An area for further development is task analysis. As the UJTL becomes a more critical and matured framework to investigate force capabilities, task analysis and management through the task analysis framework will be a critical OR capability.

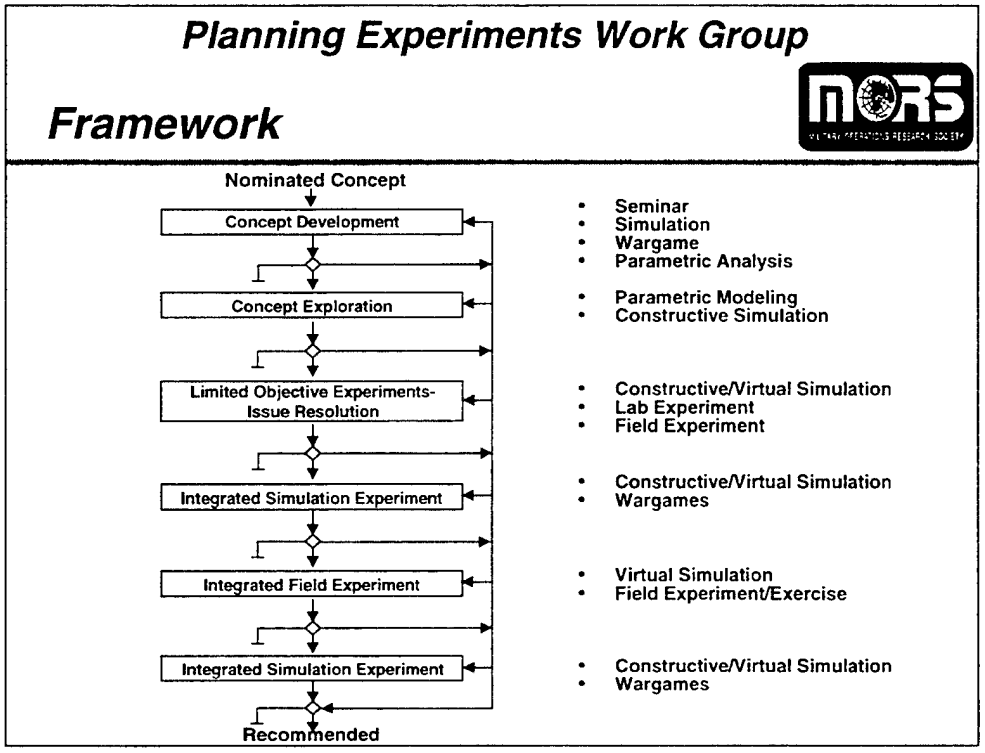
Planning Experiments Work Group

Exploration Techniques

Spectrum of Evaluation Techniques and Environments

Technique	*Resources*	*Lead Time to Create and Apply*	*Breadth of Application*	*Replicability*	*Credibility*
Expert Elicitation	Lowest	Days-Weeks/ Days	Very Broad	Limited	Variable
Wargame	Low	Weeks/Days	Very Broad	Limited	Fair
Analytical Models	Low	Weeks/Days	Broad	Fully	Fair
Lab Experiment	Low-Moderate	Weeks/Days	Limited	Fully	Moderate to Good
Constructive Simulation	Low-Moderate	Months/Days	Broad	Fully	Moderate
Virtual Simulation	High	Years/ Months	Moderate	With Difficulty	Potential for Good
Live Simulation	High	Years/Weeks	Limited	Little	Generally Good
Real Crises/ Combat	N/A	N/A	Quite Limited	None	Excellent

This chart shows possible exploration techniques and environments available for experimentation in terms of resources and lead time required, the breadth of the application, replication capability and the credibility associated with a technique. Each technique can be used by itself or in combination with any other technique.



This chart recommends a framework for concept development and experimentation. It provides an example of an iterative process and how different types of analyses and events can be structured to support a concept. Again, it is important to note that this is an iterative process and at any decision point a concept may be terminated, go back single or multiple steps or go straight to a recommendation.

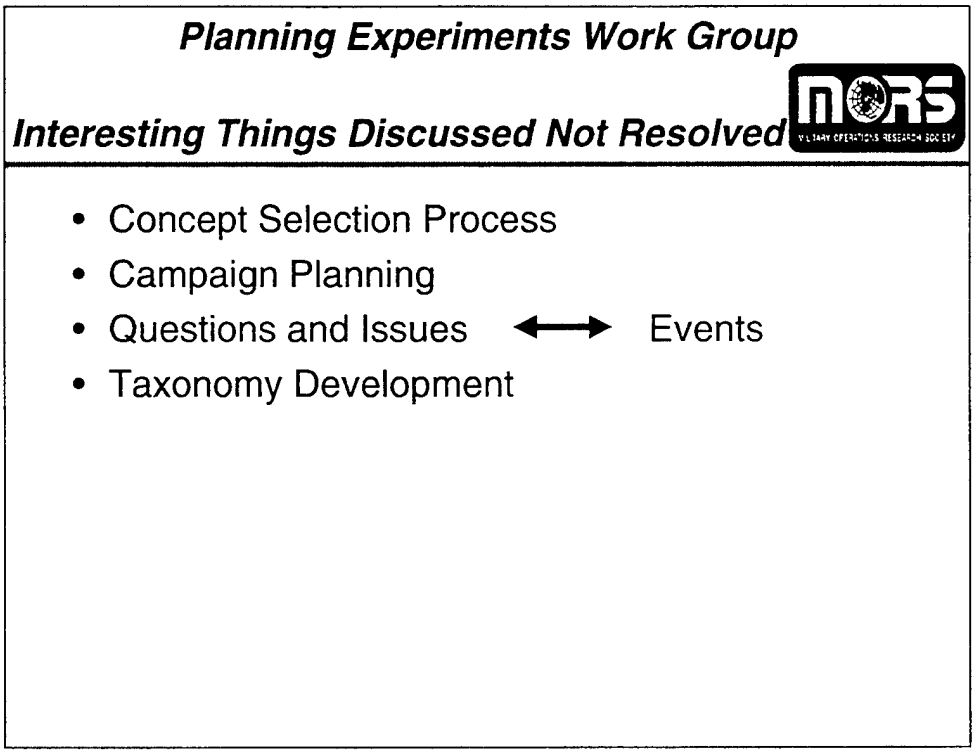
Combined with the concept development slide, this framework provides a structure to develop the Concept Strategic Plan as well as a multi-year Experimentation Campaign Plan.

Planning Experiments Work Group

Resource and Infrastructure Considerations

- Scenarios
- Tool Development
- Red Teaming/ Adversary Development
- DOTMLP Development/ EXFOR

Resources and infrastructure are important considerations throughout the entire planning process. Scenarios must be developed to provide the analytic rigor in which a concept will be explored. Tools (i.e. models and simulations) must be carefully considered in order to provide answers to issues and support MOE and MOP. Models and simulation capabilities must also be considered as drivers of live events. Red teaming and/ or opposing force capabilities must be developed to provide robust and credible adversaries in order to explore concepts.



The Planning Experiments Working Group touched on the following topics but did not focus on, or resolve, any issues related to these topics. In short, methodologies need to be developed for the selection of concepts, the planning of campaigns and the linkage of concept questions and issues with events or venues for exploration/ experimentation. Joint taxonomy must be developed for better understanding of joint experimentation among the services.

Planning Experiments Work Group

Recommendations

- OR Techniques and Analysis be applied to Concept Definition and Selection.
- Campaign Plan '00 have an enhanced articulation/common understanding of the JE Vision and end state we are pursuing.
- Use of operations research tools and techniques be planned and integrated throughout the Concept Development/ Exploration cycle.
- The current J9 Organization for Experimentation be reviewed to provide continuity in view of Concept Development, Investigation and Implementation.
- The Campaign Plan develop criteria and a decision process to make hard choices in time, resources and appetite.
- Low Resolution and Interactive Development be planned before Live Events and as part of an Model-Exercise-Model methodology.

Dick, should these recommendations read as "should be applied," "should be planned," etc.?? Corrina

The process of concept definition and selection requires thoughtful investigation and analysis and should have its own planned assessment process. Concepts should be prioritized IAW the JE vision.

There does not appear to be a common understanding of what the results of JE are supposed to be. Without this vision it is impossible to prioritize effort and measure experimental progress.

Assessment/analysis does not happen at the end of the experimental process, it is integral to it. Some of the highest payoff in assessment will be early in the concept exploration phase and must be planned and resourced. Analytic perspective must be embedded throughout the process, especially planning. Current J9 staff is long on planners and short on analysts. In its final configuration, J9 must have staff with an analytic capability involved in every aspect of experimentation.

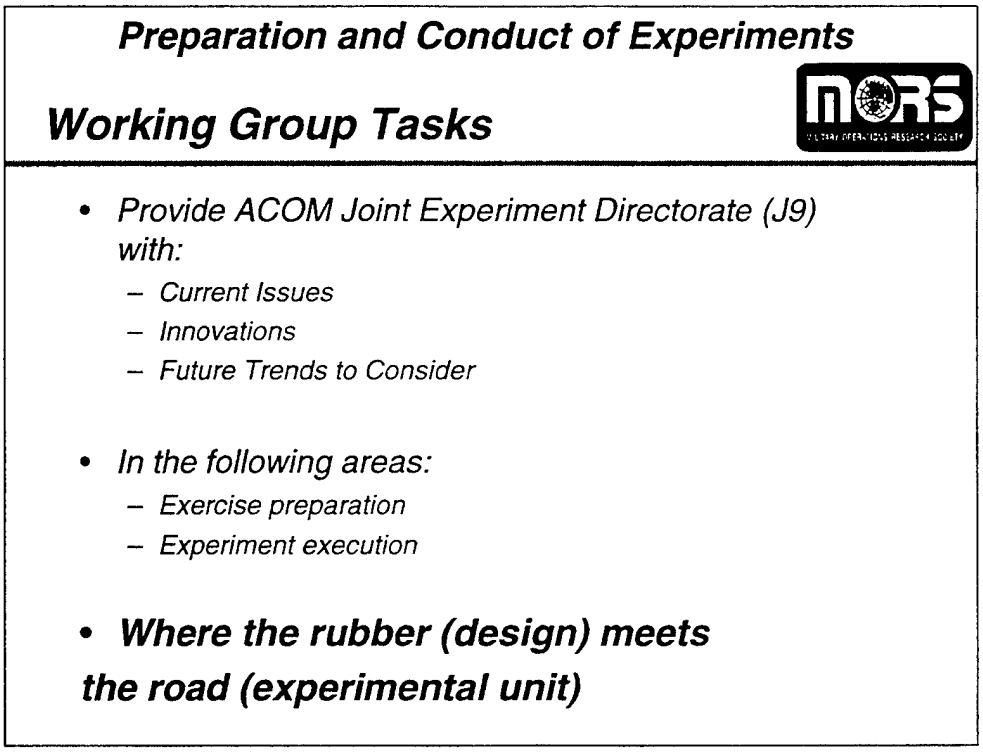
The current J9 organization follows the tradition J-staff logic, but may not be appropriate for experimentation. With an iterative, concept based approach it might be better to organize around concepts rather than functionally. This idea should be reviewed at the J9 off-site.

Currently there is a "take all concepts" approach to JE. To do things right, they must be focused. A process to make choices and prioritize should be part of the Campaign Plan and involve analysis techniques to support.

Model-Exercise-Model is a must. There is high Return On Investment (ROI) at the concept exploration part of the process that analysis can richly inform.

Joint Experimentation Workshop

Conduct of Experiments



Many individuals in and out of the government currently associated with the services battle labs and T&E agencies have years of experience in conducting separate service experiments or overlaying an experimental design on a real-world exercise or event. Participants in this work group extrapolated from these experiences to generate lessons learned concerning the preparation and conduct of joint experiments outside the laboratory.

Preparation and Conduct of Experiments

Working Group Participants

- ***Dr Rick Kass*** ***Army Test and Experimentation Command (TEXCOM)***
- ***Mr Don Kroening*** ***Army TRADOC Analysis Center -Leavenworth (TRAC-L)***
- ***COL Rick Geraci*** ***ACOM Joint Experimentation Directorate-J9 (Operations Division-J94)***
- *Participants*
- ***Mr Gary Arnett - Synergy Inc***
- ***Dr Thomas Cook - Army/ARL***
- ***Dr Richard LaFerriere - Army/TRAC***
- ***Ms Leslie Lampella - Army /HQ TRADOC***
- ***LTC Lynnette Lowrimore - AF/XOCI***
- ***LTC Chris Pate - DCSOPS***
- ***Ms Lauran Winter - Army/HQ TRADOC***
- ***Mr Dale Winzer - AF/AC2ISRC/AFEO***

The input to the working group reflects great Army and Air Force experience. One of the civilians was a retired Marine Corps officer so he provided both Marine Corps and Navy perspectives.

Preparation and Conduct of Experiments

Preparation

- ***Identify and scope experimentation hypotheses early — key***
  - *All else depends on this*
  - *Need objective way to review and prioritize hypotheses*
    - *Relevance, technical maturity, scenario impact, cost, modeling feasibility and data requirements*
- ***Early planning document development and staffing***
  - *Need early initial Management Plan*
    - *Primary issues, scope, and concept; roles, missions and responsibilities of partners; product timelines*
- ***Early identification of resource requirements***
  - *Initial and living budget*
  - *Outside personnel requirements very early (data collectors, SMEs)*
  - *Consider contracting out to existing OTAs who do this as a way of life*

The key to a successful experiment is the early identification and scoping of the hypotheses (analytic issues to be addressed in the experiment). Since the experiment is such a visible event, there will be many agencies wanting to use it for their own purposes. Prioritization of the hypotheses can be accomplished in a series of review boards that apply specific review criteria to determine the prioritization of the individual hypotheses. These prioritization criteria should include areas pertinent to the cost and ability to examine the hypothesis in the M&S and the field experiment itself.

Early planning documents are important because they provide a common understanding of the experiment to all involved. A key planning document is an early Experiment Directive (ED) which assigns responsibilities and defines the timelines for the experiment. This document must be developed early in the process and signed by a senior official with the authority to assign responsibilities. This overarching management directive can then be followed by a more detailed plan for the experiment which includes sub-plans or annexes for the management of the experiment, the M&S used in the experiment, the data collection plan and any other plan appropriate for the experiment.

Resource needs are shaped by the initiatives and hypotheses of the experiment. Start as early as possible and work actions in parallel to resource long-lead items — especially personnel resources required from external agencies. For large Joint Experiments consider "contracting" the data collection-data management to an existing DoD agency with expertise in running tests and experiments, for example, to one of the service Operational Test Agencies (OTA). They have an infrastructure of instrumentation and data management experience.

Preparation and Conduct of Experiments

Preparation

- **Scenario development**
  - *Must accommodate experimental hypotheses*
  - *Need CINC approval and service buy-in*
  - *Internal verification and external validation, iterative refinement*
- **M&S**
  - *Need to schedule sufficient time for modeling cycle*
  - *If experiment = model-exercise-model then it's not over until post-exercise modeling component completed*
  - *Collect additional data during exercise to support calibrating post-exercise modeling*
- **Deployment and set-up**
  - *Transportation - budget, priority, mode*
  - *Bed down and site set-up - personnel, logistics, communication checks*

New joint scenarios will be required if the joint concept is truly new. Joint scenarios will need to be approved at the highest level and coordinated early to get everyone to buy in. The VVA process will need to be done in parallel because of shortened timelines. The scenario refinement process for M&S and the field experiment will continue throughout the planning stage and into the conduct of the experiment itself.

Develop the M&S plans early. M&S needs a long lead time. Late breaking "good ideas" adversely impact M&S development. Sufficient time after the field exercise needs to be allocated to complete the post-exercise M&S. Of special consideration are those M&S data requirements that need to be collected during the field experiment for input into the post-exercise M&S to support the final assessment phase.

Getting experimenters (experiment controllers, data collectors, analysts, etc.) and participants (units and augmentees who play in the experiment) to the various events will be a major consideration. USACOM must budget and POM for CJCS transportation dollars to cover all planning, training and spin-up events, as well as the culminating event. Priority at least as high as CJCS-sponsored exercises must be accorded the joint experimentation infrastructure.

Responsibility for bed down of experimenters and participants may be delegated to the service components, but USACOM must set the ground rules, manage the budget, and ensure that safety, security, local transportation, billeting, messing, communications, etc. are sufficient to support the event.

Preparation and Conduct of Experiments

Preparation

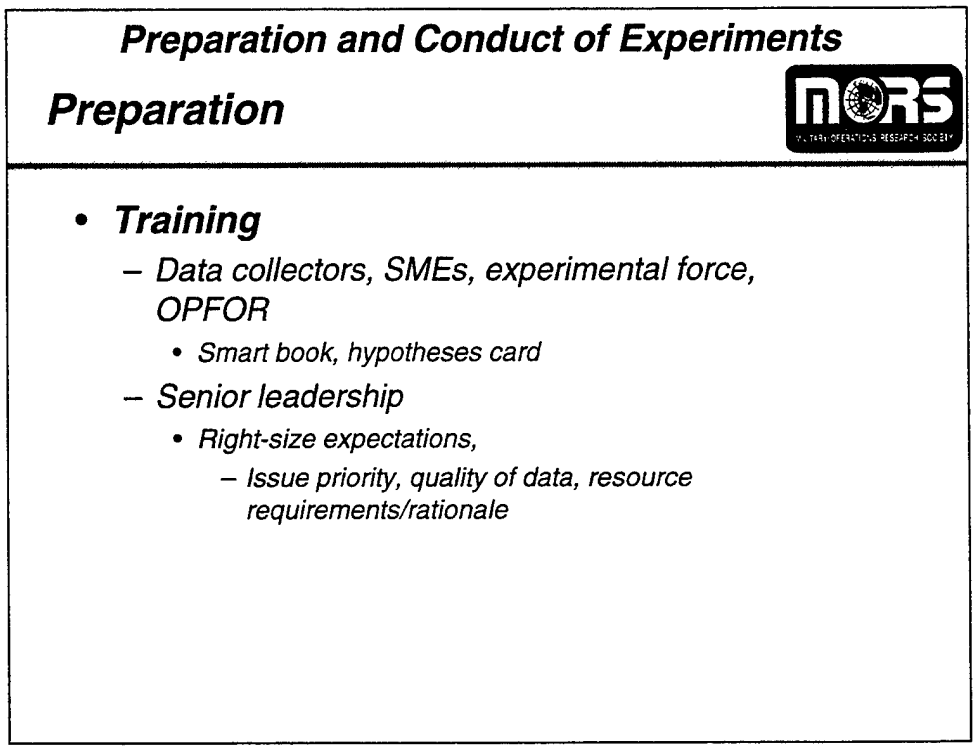
- **Data collection planning**
  - *Develop data collection requirements 6-9 months early*
    - *Instrumentation long lead item*
    - *Transparent data collection techniques (automated tools)*
    - *Quantitative and qualitative*
  - *Establish early experimental unit leadership availability requirements for surveys/interviews*
  - *Early data base development with analyst and modeler*
  - *Pilot test end-to-end!!!!*

At least 9 months prior to the experiment the analysts must provide the data collection organizers with collection requirements. The collection requirement will dictate the number, type and qualifications of SMEs/data collectors and the quantity and type of instrumentation needed. Transparent data collection techniques along with automation should be used as much as possible. Use manual data collection only when absolutely necessary.

Negotiations with the actual experimental unit are also necessary so that unit leaders and key players in the experiment will be available for in-depth interviews and surveys.

A database that meets the needs of both the collection agency and the analysis agency also needs early development.

Finally, time must be allocated for a pilot test or an end-to-end test prior to the start of the exercise. This will ensure that the collection procedures are adequate and that the analysts are satisfied with the data before the actual exercise starts.



A good method for getting a common reference for everyone involved in the execution of the experiment is to develop a "smart book" and a "hypothesis card." The smart book is specifically designed for SMEs to carry and it identifies, describes and explains all of the hypotheses/issues/initiatives in the experiment. The hypothesis card is a laminated business-size card that succinctly summarizes the goals and objectives of the experiment. One hundred percent of the participants (to include data collectors, SMEs, player unit and OPFOR) should be required to carry this card. It does not reflect well to have a VIP visit the site and ask one of the participants what they are involved in — if the participant's response is a shrug.

The senior leadership in both the CINC and service staffs need to be educated on the scope and goals of the experiment. This can be accomplished by a traveling "road show." One goal in this education process is right-sizing expectations. Another goal is to convince organizations supporting the experiment that their contributed resources are being used in a great cause and that their continued support is required and appreciated.

Preparation and Conduct of Experiments

Conduct

- **Data collection execution**
  - *Provide quick-look capability (manual and instrumented) to insure getting required data and to support daily hot-wash*
  - *Analysts access to experiment execution*
  - *Ready response cell of SMEs/data collectors*
- **Control of experiment**
  - *Need a robust control cell that includes analyst representation*
  - *Balance free play and MSEL events*
- **Visitor protocol**
  - *Resource visitor bureau — pays dividends (... but non-interference)*
    - *Standard briefing/tours (to include into experimental unit), opportunity to right-size expectations, send out invitations, VIP treatment*

It is not a good idea to wait until the experiment is completed to determine if adequate data was collected. Analysts need to ensure that the data is, in fact, coming in as the experiment progresses. This allows for data collection adjustments while the experiment is in progress. Analysts must occasionally get away from their computer printouts to view the experiment first hand and to get their own views of what is happening in order to better understand the data. Sometimes collection requirements change during execution. Additional qualified SMEs need to be on-hand to fill the gaps without diminishing other collection requirements

The exercise/experiment control cell needs to include analysts so both "impact on data collection" and "impact on experimental objectives" will be considered when contemplating scenario adjustments. The experimenter will always have to balance experimentation goals (learning/discovery) and exercise goals (training). Can both co-exist in one event without diluting the desired results due to competing objectives and requirements? Free play is desired but an experiment must generally be more structured than a training exercise.

Telling the experimentation story well is an absolute necessity. Experiments are expensive propositions. Senior leaders (service, joint and DoD) as well as Congress want to ensure the money is well spent. This political reality can not be ignored. Leaders will often want to see the experiment first hand to validate that the money is well spent. Thorough planning for visitors is critical to the success of the experiment. Visitor briefings are also an opportunity to further manage expectations.

Preparation and Conduct of Experiments

Conduct

- ***Maintain experiment infrastructure***
  - *Care and feeding of experimenter*
  - *Establish computer maintenance and separate communication networks*
- ***Hot wash briefing requirements***
  - *Don't fight appetite for immediate feedback*
    - *Establish process to support generating daily results briefings*
    - *Use process to capture insights while fresh*
    - *Train analysts to do incomplete analysis*
    - *Select credible briefer (military analysts)*
- ***Analysis and reporting***
  - *Conduct post-event analysis workshops, don't develop report in a vacuum*
  - *Produce **one integrated report** preceded by short, hard hitting "insights" memo (final report **after post-exercise modeling** — not after "field exercise")*

Sufficient resources must be allocated to keeping the experiment infrastructure and systems architectures up and running throughout the experiment. Do not depend on the player unit for computer maintenance and communication nets to run the experiment infrastructure.

The experimentation community must realize that there will be a natural requirement on the part of senior leadership to have some immediate and cyclic analytic feedback during the course of the experiment/exercise. The experimentation community should not try to resist this tendency, but rather should use it as an opportunity to update right-sizing expectations. Accordingly, the hotwash must include positive and negative findings, and be grounded in reality...it should not be a "love-in."

To facilitate the analysis (given that much of it is being conducted by groups of analysts who are geographically dispersed after the experimental event), post-event analysis workshops should be conducted. The focus of these efforts is to produce two products. The first product, an Initial Insights Memorandum (IIM), is a short accounting of the major insights drawn from the experiment, even if produced from incomplete data. This product is intended to satisfy the immediate appetite for analytic results by the senior leadership. The second product is the final report for the experiment. This report must be a single document which contains all analytic results of the experiment, regardless of who developed them. A single report is necessary to ensure that contradictory results from multiple reports are not released to the consumers.

Preparation and Conduct of Experiments

Finding/Recommendation

- ***Finding***
  - *Insufficient attention to experiment planning and execution can result in an invalid experiment*
    - *Insufficient resources*
    - *Unrealistic Expectations*
    - *Nonresponsive data collection*
    - *Inadequate analysis and reporting*
- ***Recommendation***
  - *Develop a single integrated J9 team with responsibilities to follow the experiment from concept development to final report to ensure a valid experiment.*

"An experiment without good data is just a training exercise"

It is difficult to summarize the collection of "good ideas" generated from this working group. The difficulty was not in generating insights based on the working group's experienced members, but rather in organizing the many good and varied insights into a useable product for ACOM.

If there was a consensus of the working group it would probably have focused on the proposition that the final stage "analysis of data to produce a report" needs to be represented early in the experiment design process or the desired results will not occur. This design process needs to be considered early during hypothesis generation, resource allocation and in right-sizing the expectations of the product consumers.

Preparation and Conduct of Experiments

Backup Slides

Preparation and Conduct of Experiments

Concept Hypotheses

- ***Identifying and scoping of all hypotheses - Key!***
- ***Determine "jointness" of hypotheses***
- ***Need objective way to prioritize hypotheses - (Hypotheses Review Board)***
- ***Establish review criteria***
  - *Relevance*
  - *Technical Maturity*
  - *Cost*
  - *Scenario*
  - *Modeling feasibility*
  - *Data Requirement*
- ***Top-down driven - early-on senior leader involvement***
- ***Sensitize/explain the impacts of last minute add-ons***

The key to a successful experiment is the early identification and scoping of the hypotheses (analytic issues to be addressed in the experiment). Since the experiment is such a visible event, there will be many agencies wanting to use it for their own purposes. A process must be set up to ensure that the experiment is limited to addressing only necessary hypotheses, prioritized by proper authority. In the context of joint experiments, the extent of "jointness" of the hypotheses must be determined and agreed to. The prioritization of the hypotheses can be accomplished by a formal review board, or series of review boards, which apply specific review criteria to determine the prioritization of the individual hypotheses. The prioritization criteria should include a hypothesis' relevance to the experiment objectives, the technical maturity of the systems involved, the associated costs, the ability of the scenario to address it, the feasibility of M&S to address it and the data required to represent it in the appropriate M&S. The development of potential hypotheses to be reviewed and selected for the experiment should be a top-down process driven by the senior leadership. Senior leadership must be sensitized to the fact that changes to the hypotheses late in the process can have devastating effects on the success of the experiment.

Preparation and Conduct of Experiments

Experiment Planning Documents

- ***Documents the core understanding of the experiment***
- ***Needs a balance to adequately address all of the consumers of the plan***
- ***Experiment directive/project order***
  - *Assigns the overall concept, roles, mission, responsibilities and product timelines*
  - *Developed and signed early*
- ***Best to have a single integrated plan (living document)***
  - *Management plan*
  - *M&S Plan*
  - *Data collection plan*
  - *Coordination through intermediate versions is key*
  - *Define common terminology*
  - *Coalition considerations should be addressed*
- ***Right-sizing of expectations - brief the plan***
- ***All stakeholders at highest levels sign plan***

Planning documents are key to the experiments' success because they provide a common understanding of the experiment to all involved. These plans must be balanced so that they adequately address all issues and actors involved in the experiment. For example, do not have a 50-page operations order with a one-page add-on of experiment measures of performance.

The key planning document is an early Experiment Directive which assigns responsibilities and defines the timelines for the experiment. This document must be developed early in the process and signed by a senior official with the authority to assign responsibilities.

This directive is closely followed by a single plan for the experiment which includes sub-plans or annexes for the management of the experiment, the M&S used in the experiment, the data collection plan, and any other plan appropriate for the experiment. The key is for all these planning documents to be integrated into a single plan. This plan must be fully coordinated, use common terminology and address the potential inclusion of coalition forces in the experiment.

The plan must be briefed to senior leadership, to among other things, right-size their expectations regarding the experiment.

This detailed plan must also be approved and signed by the stakeholders in the experiment who have the authority to task others involved.

Preparation and Conduct of Experiments

Resource Management

- *Impacted by initiatives/concept issues*
- *Start early; never enough lead time*
- *If budget is set, additional requirements and consequences need to be surfaced as soon as possible*
- *Management plan defines responsibilities and time lines*
- *Must identify person in charge of physical site*
- *Need a resource support plan*
- *Identify personnel to meet defined qualifications*
- *May contract existing agencies (OTAs) who have experience with experiments*

Resource needs are shaped by the initiatives and hypotheses of the experiment and constrained by the budget. There is never enough lead time. Start as early as possible and work actions in parallel. As additional resource requirements arise after the initial budget is approved, these UnFunded Resources (UFR) need to be surfaced as soon as possible along with the consequences of not resourcing in order to allow the senior decision makers time to find the resources. The management plan fixes the responsibilities and timelines for the major resources.

It is necessary to identify the person in charge of decisions regarding the physical site and insure that this person has authority to enforce decisions. The infrastructure includes offices, computers, phones, equipment and support personnel. The badging system includes Web-based registration and the in-processing system. It is critical to keep all participants informed.

One also needs a resource support plan and a disciplined approach to resourcing,and to identify resources for each phase of MEM. It is necessary to develop tasking for the people and equipment to meet the timelines. Participating units should provide their own infrastructure. Floor plans to identify location of experimenters and to assess their impact on the operators are also required.

Subject Matter Experts (SME) should be identified by qualifications and quantity to support the experiment as data collectors, and to identify equipment they may require. Task agencies who provide SMEs early on. Have a vetting process so if the SME provided does not meet SME qualifications (e.g., rank, combat experience, specialty), he or she can be replaced.

For large Joint Experiments consider "contracting" the data collection-data management to the expertise of an existing DoD agency with expertise in running tests and experiments, e.g., to one of the service operational test agencies. They have an infrastructure of instrumentation and data management experience.

Preparation and Conduct of Experiments

Scenario development

- *Scenario should be concept-driven; needs to reflect experimental objectives*
- *Representative 'Joint' flavor*
- *CINC approval and Service buy-in*
- *Consider both internal verification and external validity*
- *Iterative refinement through execution*

Developing scenarios for joint operations will not be easy given the newness of the endeavor and the requirement to get the services to buy in. New joint scenarios will be required if the joint concept is truly new. The scenarios need to be approved at the highest level and coordinated early to get everyone to buy in. The VVA process should be done in parallel because of shortened timelines. The scenario refinement process will continue throughout the planning stage and into the conduct of the experiment itself.

Preparation and Conduct of Experiments

M & S

- ***Determine M&S capabilities to support concept experimentation***
- ***Develop M&S plan early (always a long lead time)***
  - *Plan M&S support for all experimentation phases*
  - *Identify data requirements*
  - *Identify M&S resources*
- ***Federation of M&S needs to be considered for Joint operations***

Determine M&S capabilities to support concept experimentation: What can M&S do and not do? Can the issue be modeled? Can the issue be simulated during the field phase? Can the data be obtained/collected?

Develop M&S plans early. Late breaking "good ideas" adversely impact M&S effectiveness. Early-on fix responsibility, identify data requirements and data inputs. The data providers, approvers and arbitrators for this process need to be identified also. A special consideration are the M&S data inputs that need to be collected during the field experiment for the M&S post-exercise assessment phase. Identification of resources for M&S is also necessary — VVA, equipment, any unique development, connectivity, M&S players, security and floor space.

Also consider a federation of M&S to address all joint participants and capabilities. Review appropriate analytical and training M&S to address experimental issues.

Preparation and Conduct of Experiments

Deploy and Set-up

- ***Transportation***
  - *Budget (POM, FINPLAN, resource management)*
  - *Priority (establish CJCS priority)*
  - *Mode (air, sea, road-haul)*
- ***Bed down***
  - *Personnel support organization/DRMD*
  - *Force protection*
  - *Billeting/messing/local transportation/medical*
  - *Communications*
- ***Set-up***
  - *Testing/comm checks/maintenance/contractor support*
  - *Calibration of instrumentation*
- ***Redeployment/reconstitution/cleanup***

Getting experimenters (experiment controllers, data collectors, analysts, etc.) and participants (units and augmentees who play in the experiment) to the various events is a major consideration. USACOM must budget and POM for CJCS transportation dollars to cover all planning, training/spin-up events as well as the culminating event. Priority at least as high as CJCS-sponsored exercises must be accorded joint experimentation.

Responsibility for bed down of experimenters and participants may be delegated to Service components, but USACOM must set the ground rules, manage the budget, ensure safety, security, local transportation, billeting, messing, communications, etc. are sufficient to support the event.

Sufficient time and resources must be allocated for set-up, testing, calibration, etc. to ensure the experiment architectures are capable of supporting the event and that a suitable environment is provided to support the various experiment trials/initiatives.

Experiment sites must be returned to a condition equal to or better than what existed before the experiment. Budget and resources must be sufficient to cover cleanup and redeployment of experimenters and participants.

Preparation and Conduct of Experiments

Data Collection Planning

- ***Develop data collection matrix (requirements) 6 to 9 months prior to experiment (Joint effort with analysts)***
  - *SME/data collector requirements (tasking #'s, qualifications, laydown, training, continuity)*
  - *Instrumentation (development, laydown, non-obtrusive)*
  - *Interviews/surveys*
  - *Collection techniques (automated, manual)*
- ***Consolidated database development (Joint effort with analysts)***
  - *Management*
- ***Pilot Test - End-to-End***
- ***Data collection must include OPFOR***

It is important to ensure that the data collection managers be brought in early in the process. At least 9 months prior to the experiment the analysts should provide a good idea of the collection requirements. The collection requirement will dictate the number, type and qualifications of SMEs/data collectors and the quantity and type of instrumentation required. Once this is known the data managers can begin the process of acquiring (tasking for) SMEs/data collectors and obtaining or developing the required instrumentation. This process can be very time consuming depending on the requirements. Automation should be used as much as possible to support manual data collection. Concurrently the data managers can begin developing a database that meets the needs of both the collection agency and analysis agency. Finally, time must be allocated for a pilot test or an end-to-end test. This will ensure that the data collection process is collecting the correct data and that the analysts are satisfied with the data.

Preparation and Conduct of Experiments

Training

- ***Must educate senior leaders on experiment issues and impact of changes***
- ***All need to be aware of the goals and objective of the experiment and role of others***
- ***EXFOR needs TTP, TSP, NET and train-up***
- ***OPFOR needs train-up***
- ***Experimenters***
  - *Need specific training*
  - *Smart book and hypotheses card*

This area might as well have been called education instead of training. The senior leadership in the CINC and the service staffs need to be educated on the scope and goals of the experiment. This can be accomplished by a traveling "road show." One goal in this education process is right-sizing their expectations. Another goal is to convince them that any resources they are "contributing" are being used in a great cause and their support is required.

Another key method for getting everyone involved in the experiment on the same page is to develop a "smart book" and "hypothesis card." The smart book is specifically designed for SME's to carry and it identifies, describes and explains all of the hypotheses/issues/initiatives in the experiment. The hypothesis card is a laminated business-size card that succinctly summarizes the goals and objectives of the experiment. One hundred percent of the participants (to include data collectors, SMEs, player unit and OPFOR) should be required to carry this card.

Preparation and Conduct of Experiments

Data Collection Execution

- ***Resources and requirements must be identified early in order to manage data collection/ instrumentation/data base population and the quality control process***
- ***Provide quick-look capability (manual and instrumented) to insure getting required data and to support daily hot-wash***
- ***Provide analysts access to experiment and data base***
- ***Establish a data review process to validate subjective data***
- ***Ready response cell of SMEs/data collectors***

Throughout the experiment the data collection manager must continue to work with the analysts and provide data as soon as possible. It is not a good idea to wait until the experiment is completed to determine if adequate data was collected. Analysts need to ensure that the data is, in fact, coming in as the experiment is in progress. This allows for the possibility to adjust data collection as the experiment is in progress.

Analysts must occasionally get away from their computer printouts to view the experiment first hand and to get their own views of what is happening in order to better understand the data.

Because there are many stakeholders in the data, a formal data review process should be established to authenticate the data prior to releasing the database for final analysis. It is especially important to review all comment data for relevance and veracity.

Sometimes collection requirements change or arise during execution. The data managers should have a handful of qualified SMEs to fill the gaps without taking away from other collection requirements.

Preparation and Conduct of Experiments

Control of the Experiment

- *If experiment is in conjunction with a training exercise, then must balance training objectives with experiment objectives*
- *Need a robust control cell that includes analyst representation*
- *Balance free play and MSEL events*

Piggy-backing experiments on service exercises is probably a reality for some time. There will be continual negotiations to insure the experimental objects do not get lost. Need to establish a cell to continually monitor this process. Even if a "pure" experiment is conducted, there still needs to be a balance between achieving specific tasks versus the free play operational realism of the unit.

Preparation and Conduct of Experiments
Protocol/Marketing/Visitor's Bureau

- **Visitor protocol**
  - *Resource visitor bureau — pays dividends (... but non-interference)*
    - *standard briefing/tours (to include into experimental unit), opportunity to right-size expectations, send out invitations, VIP treatment*
  - *Need high-level support to enforce "no additional data collectors / observers"*
  - *Consider virtual visitor bureau*

Experiments are expensive propositions. Senior leaders (service, joint and DoD) as well as Congress want to ensure the money is well spent. We cannot ignore the political reality....they will want to see the experiment firsthand to validate that the money was well spent. Therefore, thorough planning for visitors is critical to the success of the experiment. The difficulty lies in the creative tension between visitor support (especially as the rank of the visitor increases) and not interfering with the experiment itself. Collectively, this could be called "experimentation marketing." Resourcing a force to manage this "campaign" is critical to its success. Invitations for very senior leaders is a long-lead time item and will be subject to numerous perturbations as scheduling conflicts appear. Determining what should be on the visit itinerary, appropriate protocol to be rendered etc., take time, effort and especially attention to detail. Ensuring that the invitation list (and more importantly those that "invite" themselves) is manageable also requires senior leader oversight. Expectation management is another critical component.

Preparation and Conduct of Experiments
Maintaining Experimentation Infrastructure

- **Care and feeding of experimenters**
  - *Shift schedule coordination*
  - *Transportation needs*
  - *Communication needs (cell phones, fax)*
  - *Lodging/messing/medical*
- **Computer/communication networks**
  - *On site maintenance support*
  - *Dedicated networks*

Once the experiment begins it is critical that the different elements comprising the experimental environment receive proper attention by the operations group. The various aspects of the infrastructure require "care and feeding" to ensure that the live experiment is properly supported and completed on schedule. The major parts of the infrastructure consist of the personnel (experimenters) conducting the experiment and the equipment needed to support the experiment.

Basic needs of the experimenters during the experiment include lodging, food, transportation, medical, and communication. The numbers of personnel conducting the experiment and the duration of the experiment are key drivers for these support areas. Another issue is the experimenter shift schedule. If an insufficient number of experimenters is used, the shift schedule can become infeasible or so stressful it will adversely impact the overall conduct. Health of the experimenter group needs to be maintained to prevent any possible shutdown of different parts of the experiment. Consider requirement estimates for "supernumeraries" for key experimental staff an adjustment factor for members who may become ill to provide for alternate or "back-up."

Equipment to support the conduct of the experiment includes such items as the computer hardware and software, communications network, transportation, repair parts and power generation used by the experimenter staff. Maintaining computers, the related Local Area Network (LAN), and the distributed network is critical. An on-site dedicated technical maintenance support center to provide responsive computer support should be considered. If possible, a dedicated communications network should be used for the experiment. The transportation and power generation equipment requires a maintenance staff to do daily checks. The maintenance staff needs an adequate level of spares to repair equipment.

Preparation and Conduct of Experiments

Hot Wash Briefing Requirements

- ***Don't fight the appetite for immediate analytic feedback***
- ***Establish a process for generating daily or cyclic analytic feedback***
- ***Use the process to capture analytic insights while fresh***
- ***Train analysts to do analysis of incomplete data***
- ***Select credible briefer (military analysts)***

The experimentation community must realize that there will be a natural requirement on the part of senior leadership to have some immediate and cyclic analytic feedback during the course of the experiment/exercise. This is mainly caused by the need to show some immediate results to those who provided the large investment of time and dollars in the experiment. The experimentation community should not try to resist this tendency, but rather should use it as an opportunity to conduct some level of analysis during the exercise while the events are still fresh in their minds.

A process for conducting analysis, which leads to this feedback, must be established. Feedback should be expected on a daily basis, or perhaps on some other cyclic basis (e.g. at the end of each phase of a scenario).

The analysts must be trained to conduct analysis on incomplete data in order to produce this immediate analytic feedback. This will be uncomfortable to most analysts who prefer to have the complete set of data from the experiment.

These analytic results should be presented by an analyst who is credible in the eyes of the audience (probably the senior leadership). In the case of major experiments, this will most likely be a military analyst.

Preparation and Conduct of Experiments

Analysis and Reporting

- ***Apply the Model-Exercise-Model (MEM) approach, if possible***
- ***Establish a process for conducting analysis throughout the experimentation process***
- ***Focus analysis on potential capabilities, not specific systems***
- ***Conduct post-event analysis workshop(s). Experiment is not concluded until MEM is completed.***
- ***Produce one integrated report preceded by a short, hard-hitting Initial Insight Memo***

When possible, the Model-Exercise-Model (MEM) analysis approach should be used for experimentation so that the complete set of analytic issues are addressed by the appropriate tool, whether that be a model, or the live exercise event. This requires the establishment of an analytic process which will enable initial analytic conclusions to be drawn using incomplete data from the exercise.

Because an experiment is not typically used to directly support the material acquisition process, it should focus on the identification and evaluation of potential capabilities demonstrated within the experiment, not on the evaluation of specific systems.

To facilitate the analysis, given that much of it is being conducted by groups of analysts who are geographically dispersed after the experimental event, post-event analysis workshops should be conducted. The focus of these efforts is to produce two products. The first product, an Initial Insights Memorandum, is a short accounting of the major insights drawn from the experiment, even if produced from incomplete data. This product is intended to satisfy the immediate appetite for analytic results by the senior leadership.

The second product is the final report for the experiment. This report must be a single document which contains all analytic results of the experiment, regardless of who developed them. A single report is necessary to ensure that contradictory results from multiple reports are not released to the consumers.

Joint Experimentation Workshop

Modeling and Simulation WG

Agenda

- *Participants*
- *Working Group Tasks*
- *Working Group Results*
- *Key Issues and Questions*
- *Actionable Recommendations*

Modeling and Experimentation

Working Group Participants

Name	Organiation	Email
Bob Alexander	SAIC	alexander@std.saic.com
Joe Cummings	JSEAD JTF	cummings@jsead.com
MAJ Ken Dzierzanowski	J97/J98	dzierzan@jwfc.js.mil
CAPT Bob Eberth	N85/MCWL	eberthr@mcwl.quantico.usmc.mil
MAJ Ike Eichenberger	ACOM J95	eichenb@acom.mil
Colleen Gagnon	Metron, Inc.	gagnon@ca.metsci.com
Bob Graebener	IDA	rgraeben@ida.org
Bryan Hartwig	BMDO/JNTF/Sparta	bhartwig@jntf.osd.mil
Jim Hoffman	SETA Corp.	hoffmanjc@js.pentagon.mil
Steve Husak	Litton-TASC	shusak@eris.net
Bob Kerchner	RAND	kerchner@rand.org
Tom Loncarich	TRAC-WSMR	loncarit@trac.wsmr.army.mil
Lana McGlynn	ODUSA (OR)	mcgyla@hqda.army.mil
Ken Mellin	J8 COLSA	kmellin@erols.com
Dave Nobel	EBR	dnoble@ebrinc.com
Bob O'Neill	ESC/DIS	oneillr@hanscom.af.mil
Anne Patenaude	SAIC	anee.m.patenaude@cpmx.saic.com
Al Sciarretta	Quantum Research Int'l	asciarreta@quantum-intl.com
Steve Upton	Los Alamos Nat'l Lab	upton@lanl.gov
LTC Mark Woempner	TRAC-WSMR	woempnem@trac.wsmr.army.mil
Michael Wright	ESC/DIS	mewright@mitre.org
Susan Wright	IDA	sjwright@ida.org
Anita Zabek	DMSO MITRE	anita@mitre.org

The members of the working group (and subsequent sub-working groups) drew heavily from active duty military, academic and private sector experts representing a broad cross-section of the Modeling and Simulation (M&S) community. Direct experience in the planning, staging and development of Joint Experiments (JE) provided the expertise needed to scope and bound major problems.

Modeling and Experimentation

Working Group Tasks

- *Address Modeling and Simulation (M&S) aspects of terms of reference within a Model-Experiment-Model framework*
  - *Identify methodologies and tools*
  - *Identify critical M&S issues in concept development/ planning, experiment conduct, and exploitation*
  - *Identify ways to federate and utilize existing models Evaluate characteristics of available models to assess their applicability to experiments*
  - *Identify requirements for future M&S capabilities*
  - *Establish practical limits to M&S in large scale experiments*

The working group focused on those aspects of the conference Terms of Reference (TOR) most pertinent to M&S within the model-experiment-model notional framework. The group applied the following three criteria to select issues to explore and report:

- Joint Application - the issue is important for joint experimentation rather than single service application.
- High impact - the issue has a significant impact on joint experimentation.
- Consensus - the conclusion reflects the consensus of the working group (and in some cases the sub-working group).

To develop the material for this report, the working group divided into four smaller groups that discussed the following:

1) Use of M&S for concept development.

2) Experiment design.

3) The conduct of the experiment.

4) Exploitation of experimental results.

Because the working group felt that they lacked sufficient experience and exposure to experimental campaigns, the group chose not to form a fifth subgroup to address use of M&S to support experimental campaigns. However, each of the subgroups did address experiment campaign issues as part of their work.

Modeling and Experimentation

Working Group Results (1 of 5)

- *Methodologies and tools*
  - *For Exploiting experiment*
    - *For identifying cause and effects chain*
    - *For conducting excursions*
    - *For conducting sensitivity analysis*
    - *For determining parameter values*
    - *For feed forward*

M&S can support joint experimentation by helping experimenters to represent the future by reducing costs and by increasing/enabling range safety. Models and simulations can provide continuous support throughout an experimental campaign. They can help establish concept baselines for future explorations. By requiring the knowledge to be represented fully and explicitly, they can improve knowledge acquisition. The types of tools used changed during the experimental campaign. The tools used later in the campaign are generally more refined and complex than those used earlier in the campaign.

The exploitation group examined methodologies and tools in depth. Their analyses recommended methods for reconstructing the experiment, examining unplanned opportunities resulting from the experiment, identifying cause and effects chain, conducting excursions, conducting sensitivity analysis, feeding forward results into subsequent events in the experimental campaign and summarizing and disseminating results.

M&S can support joint experimentation by helping experimenters to:

- Document the growing understanding of the conceptual doctrine, organization or technology being examined.
- Understand how the concept improves achievement of specified objectives.
- Refine the completeness and coherence of the concept.
- Assess the feasibility of a concept.
- Illustrate the dynamics of variables, identify causal relationships and demonstrate the implications of these relationships.
- Refine the scenario space (e.g., it helps experimenters examine where a concept has the greatest impact, and/or where it's contribution is most limited).
- Examine the impact of specific threats, countermeasures and performance required to overcome countermeasures.

The working group decided not to discuss specific models by name but instead to focus on model characteristics important to different applications of M&S. This decision facilitated achievement of workshop objectives by removing the potentially divisive comparisons of model capabilities.

Modeling and Experimentation

Working Group Results (2 of 5)

- *Practical limits of M&S*
  - *Multi-level security*
  - *Unable to model relationships that are not understood in the real world*
  - *Ability to rapidly represent new concepts*
  - *Inability to build a predictively accurate model of a chaotic process*
- *Deficiencies of current M&S*
  - *Various service models lack credibility among sister services of joint domain*
  - *Lack of High Level Architecture (HLA) compliance, interfaces to real world systems/cross-level representation and semantic commonality/logical consistency among federates*
  - *Models do not adequately reflect **impact of** C4ISR, IO, human behavior (individual and group), logistics, WMD and geophysical environment on weapon system and sensor performance*
  - *Inadequate environmental representations (common representations - databases, dynamic effects, interactions of terrain, ocean, DTED limits*
  - *Ability to represent Operations Other Than War (OOTW) and Military Operations in Urban Terrain (MOUT) largely non-existent*
  - *Lack of adequately verified and validated tools*

The working group distinguished between "Practical Limits" and "Deficiencies." "Practical limits" addressed limits that are fundamental to the nature of M&S and (arguably) cannot be resolved. "Deficiencies" are current shortfalls that the working group deemed correctable.

One practical limit of particular interest was the inability to build predictively accurate models of chaotic processes. Building predictive models of many non-chaotic processes, including adversary responses, remains a very difficult (if not impossible) problem whose difficulty may be neither fully understood nor appreciated by many consumers of M&S.

The following elaborates on several of the current deficiencies in M&S:

- Lack of model credibility among sister services of joint domain. Workshop participants generally felt that each service lacks confidence in models developed by sister services. Each service believes that sister services do not represent the issues adequately for their needs. For example, the Air Force may feel that the Army's ground war models do not represent the air war as required to meet Air Force needs. Similarly, the Army may feel that Air Force air combat models do not replicate ground combat as needed. The failure of overlapping regions of each model to agree supports this view. In addition, trying to analyze joint experimental results using service-specific simulations impedes the ability to gain insights into the synergism of joint operations.
- Inability to model impact of communications and human behavior. Though models can adequately represent the dissemination of information, it is difficult to show how people process and use the information to make decisions. Therefore, the assessment of the contribution of information technologies to performance and effectiveness is often difficult and incomplete.

Modeling and Experimentation

Working Group Results (2 of 5 cont.)

- Difficulty in representing new concepts using existing models or data. Futuristic systems or concepts, that by their very nature are not well defined, require significant changes in the assumptions of the existing model. Required model modifications increase costs and lead time to prepare models.
- Lack of models that represent OOTW and MOUT. Most current models are tailored for mid- to high-intensity conflict. Because emerging missions such as operations other than war or military operations in urban terrain are complex and not well understood, changing existing models or developing new ones able to address this environment will take time and significant resources. The next generation of models and simulations must address this changing world situation.
- Lack of model output able to support new MOEs, MOPs for emerging missions. Most current models, built to examine firepower and maneuver warfare, do not produce products that relate easily to the Measures Of Effectiveness (MOEs) and Measures Of Performance (MOPs) appropriate to new emerging missions. New concepts, such as information operations and network centric warfare will require new analytical techniques to produce the needed MOEs and MOPs. For example, there is a need for models that show the effects of psychological operations, non-lethal weapons and suppressive effects.

Other deficiencies of current M&S, in addition to those in the viewgraph, include:

- The lack for scenario stability such as would be provided by a standard illustrative DPG scenario.
- The lack of common approaches to standard scenario elements, including lack of a common approach to missile endgame.
- The lack of balance within models between size, force and level of representation.
- The need for interfaces to real world C4I systems and coalition models.
- A lack of awareness of the dangers involved with examining new concepts with models developed for previous studies and analyses.

Modeling and Experimentation

Working Group Results (3 of 5)

- *Federation and use of models*
  - *Integration requirements and ways to meet them*
    - *Guidance provided by Defense Modeling and Simulation Office (DMSO) Federation Execution and Development Process*
    - *Integrate with concept*
    - *Integrate with system of systems (human, C4ISR, federates, training plan, data collection (instrumentation and analysis), Verification, Validation and Accreditation (VV&A)*
    - *Integrate with warfighter confidence*

Use of the Defense Modeling and Simulation Office Federation Execution and Development Process (FEDEP) is highly recommended, particularly the checklist for federations designed for experiments, related security and verification, validation and accreditation overlays.

Before the experiment is conducted, the simulation must be modified to best mirror the concept being evaluated. This may be accomplished by federating models that properly address different aspects of the concept.

Consideration for integration of supporting models and simulation tools must occur throughout the experimental process (starting with concept development and ending with exploitation). This integration should occur continuously and iteratively, as in spiral development. For example, as the concept is modified, so must the supporting models and simulation tools.

Within this integration effort, a system of systems approach must be used. This approach should consider human participants/observers/controllers, C4ISR systems, federates, training plans, data collection (instrumentation) and analysis resources and V&VA resources. To support accreditation and "buy-in," the warfighter must establish confidence in M&S. The accreditation process must identify and address all stakeholders' issues. If accreditation cannot be achieved, then the experimental results will not be accepted by the warfighter (user/customer).

Modeling and Experimentation

Working Group Results (4 of 5)

- *Model selection criteria*
  - *Operational (ability to support functional description of the experiment, level of aggregation, terrain and environment, scope, resolution)*
  - *Has a representation that is both necessary and sufficient for concept being explored (avoid unnecessary detail)*
  - *Verification and validation status and warfighter confidence*
  - *Technical (number of units, time-management, run speed, interoperable with other simulations and systems, reuse, security level)*
  - *Resource availability (database availability,development time, portability, support staff, facilities, equipment)*
  - *Milestone and timeline constraints*
  - *Human involvement, C4ISR (real/synthetic representation)*
  - *Potential for reuse in overall experimentation campaign*
  - *Modification requirements and risk*
  - *Adequacy of Configuration Management (CM)and Life Cycle Maintenance process (LCM)*

There are many criteria for selecting the appropriate modeling and simulation tools. Selection criteria include:

- Experiment objective. Ability to support the experiment objective is the most important consideration. It includes the ability of the M&S tools to produce the data needed by the evaluation metrics; and to address the appropriate levels of warfare, current or future capabilities, and systems and doctrine. The model must have the level of resolution required to capture the desired representations. The model should fit the problem, not the problem to the model.

- Representation of needed detail. Complexity and detail should be introduced when needed, and avoided when not needed. For example, experiments that emphasize environmental representation effects (e.g., IR and MMW reflective properties of vegetation) require models and simulations that can capture that level of detail.

- Verification and Validation. Accreditation is needed both for general and particular uses of the model. Verified and Validated (V&V) tools should be used as often as possible. If a non-V&V tool must be used, then time and resources must be allocated to achieve V&V. If not, experimental results may be suspect. Note that V&V is less important early in the experimental campaign.

- Ease of integration. In live and virtual simulations, the integration of real-world C4ISR systems is critical. C4ISR-simulation interfaces have usually been developed as point-to-point solutions since modular interfaces are not readily available. One should select models and simulations that already have existing C4ISR-simulation interfaces or support development of an interface.

Modeling and Experimentation

Working Group Results (4 of 5 cont.)

- The availability of resources. One must first leverage what is available for the live portion of the experiment and then fill in gaps with constructive and virtual simulations. Other resource considerations are personnel (DoD and contractor) available to support the experiment, facilities and equipment (including hardware, software, databases) and other logistical considerations.

- Milestone constraints. These include the time period designated for the experiment (within the experimental campaign plan). The set-up time and/or modification time required for the employment of a particular tool must fit into the allotted schedule.

- Roles of people. Human involvement requires use of virtual or live simulations. Synthetic representations of humans and their decision processes are not mature enough to be credible within constructive simulations.

- Support to long term interoperability and reuse. During the earlier phases of the experimental campaign, model and simulation selections should consider the candidate model's ability to support long term interoperability and reuse for follow-on experiments within the experimental campaign plan. Models should be HLA compliant. Data driven models that are easy to change, (particularly for unit behavior and C2 relationships) are recommended.

- Ability to support the data collection plan. Proper instrumentation facilitates data collection. It does not, however, address all data collection requirements, especially data collected from SME controllers and qualitative data.
- Standard issues of Multiple Levels of Security (MLS). The collaborative, distributed nature of these experiments compounds the MLS problem.

Modeling and Experimentation

Working Group Results (5 of 5)

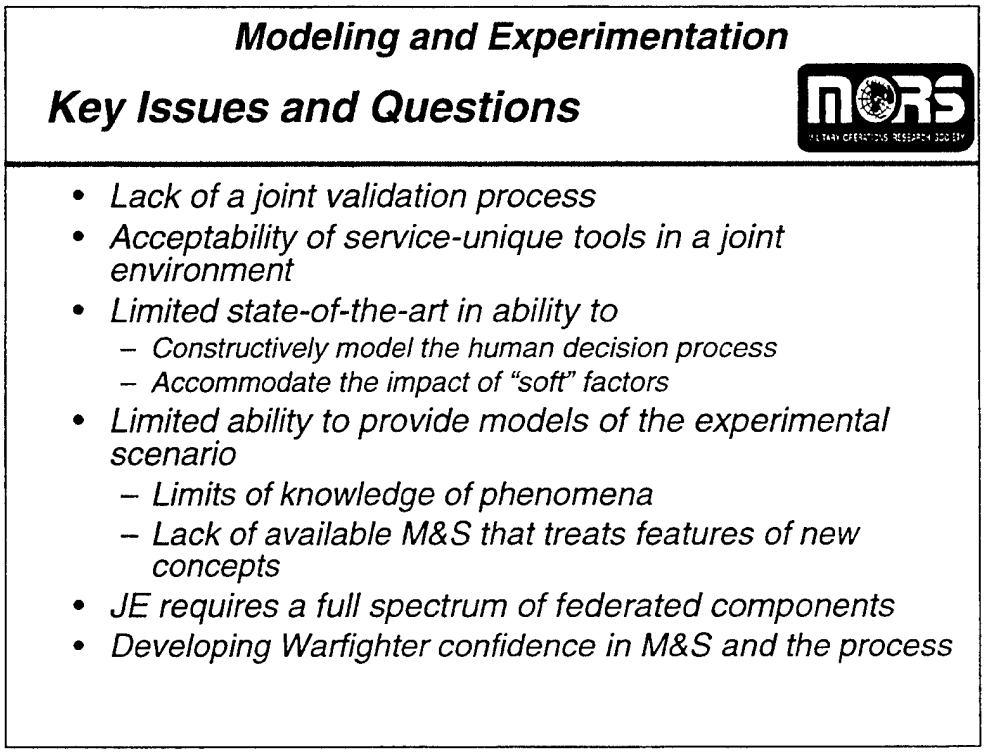
- *Requirements for future M&S capabilities*
  - *VV&A process for joint models and joint use of Service models*
  - *Broader use of class accreditation where appropriate*
  - *Data-driven models that are easy to change, particularly for unit behavior and C2 analyses*
  - *Approved joint future scenarios and an agreed to set of baseline standard future scenarios*
  - *Ability to collaboratively plan and execute actions from geographically distributed locations*
  - *Direct observable results (real-time feed back)*
  - *Predictively accurate large scale models*
  - *Input and output linkage to real systems*
  - *HLA compliance*

Models and simulations have many shortcomings in representing the real world. Perhaps the most significant current limitation concerns the availability of predictively accurate large scale models. For most experimentation purposes, models must be sufficiently accurate so that the conclusions about the concepts being evaluated are valid. Areas where sufficient predictive accuracy is not currently available include representations of human behavior, logistics, some environmental effects within joint scenarios.

- Human behavior. The representation of human behavior and of human cognitive processes is recognized as a major issue within the DoD M&S community. This shortfall impairs our ability to model the impact of advanced C4ISR systems and information operations on human decision processes, and of human decision processes on mission outcome. The working group believes that near-term solutions for this shortfall are unlikely.

- Logistics. The effect of logistics (especially shortages) on operational decision-making is also not properly modeled.

- Environmental models. Environmental models remain inadequate to support many aspects of joint experimentation. Such modes either do not exist or are too computationally intensive to support evaluations of weapon system and sensor performance within simulations. It has also been difficult to identify V&V'd models of the dissipation and effects of WMD. Computational fluid dynamic approaches are still too immature and processing-intensive to provide acceptable models, especially in built-up areas. Adequate environmental representations should include common database representations, dynamic effects and interactions (holes are left by bombs, rain causes mud and swollen rivers, waves wash away beaches, tides change, etc.), and greater accessibility of higher resolution databases.
- Approved joint future scenarios (scenario stability). It is important to understanding better the relative merit of having one joint scenario across multiple experimental events or of tying service specific scenarios to each other. We need to understand better the requirements for seamless scenarios.



This slide reiterates the issues that the working group felt were most important. Annotations elaborating on these items accompanied the viewgraphs where the issues were first presented. Summaries of the annotations are:

- Lack of joint validation process. This lack impacts the inter-service acceptability of tools developed by one service principally for their own use.

- Acceptability of service-unique tools in a joint environment. Lack of cross-service credibility stems from differences in types of issues that are modeled and objectives of the model. Often, the overlapping regions of each model tend to disagree.

- Limited ability to constructively model the human decision process. It is difficult to understand, and hence model, how people use available information to make decisions. Consequently, it is difficult to assess the contribution of information technologies to performance. Analyses of information effectiveness are difficult and incomplete.

- Ability to provide models of the experimental scenario. Most current models are tailored for mid- to high-intensity conflict. There is limited ability to represent OOTW and MOUT. Addressing this limitation will likely require significant resources, both because of limits of knowledge of phenomena and because of lack of available M&S that treats features of new concepts.

- M&S that plays in a full spectrum of JEs requires federated components. HLA federates are not readily available. Creating new federations are difficult. Needed federations are not usually available "off the shelf." Bringing legacy models into HLA compliance is often impractical.
- Developing warfighter confidence in M&S and processes. Because it is difficult to understand the assumptions and processes employed by models, warfighters cannot be confident that model results are valid for the purposes of any particular experiment objective.

Modeling and Experimentation

Actionable Recommendations (1 of 2)

- *DMSO sponsor "tiger team" to identify process to better integrate modeling and simulation tools into the joint experimentation process*
  - *Would support on-going simulation based acquisition effort*
- *DMSO Environmental Technical Working Group examine and report on the standard characteristics necessary for uniformity of a global terrain database*
- *J-9 identify a sponsor to establish guidelines for using training and analysis tools in experimentation*
- *Consider live simulations for OOTW experimentation*
  - *Evaluate current OOTW tools*
  - *Develop requirements for new OOTW models and simulations; especially models of non-lethal weapons*
- *DMSO V&V technical working group establish formal VV&A process for joint M&S and joint use of service M&S*

- DMSO sponsor "Tiger Team." Since joint experimentation is so new, the working group felt that a short-term team (sponsored by DMSO) should be organized to better understand the process of integrating M&S into joint experimentation.

- Need for uniformity in terrain database. The demand for terrain at various locations around the world requires a standardized approach to ensuring a consistent/seamless product that can be used by joint and service-specific experiments.

- Training guidelines. Training tools emphasize realism for human operators and sometimes lack physics-based details. Analysis tools are robust in physics-based representations, but often lack realism. A balance must be struck between the two if detail is required and realism is desired.

Modeling and Experimentation

Actionable Recommendations (2 of 2)

- *Adopt model-experiment-model approach*
- *Develop common joint semantics*
- *Ensure that concept and design phases are continuous and iterative*
- *Appropriately use humans and live systems for assessing impact of information operations and C2 systems*
  - *Capture decision making data to support development of human behavior representations*
- *Participate in future M&S development and enhancements (e.g., JWARS, Combat XXI) to ensure their suitability to support JE*
- *Use a decision matrix to select best M&S tools for supporting each experiment*

- Common joint semantics. An example of lack of common semantics is in use of the term "exercise." The Army says it is an exercise, not an experiment. The Air Force says the opposite.

- OOTW for live simulations. OOTW are typically not well represented in current M&S tools (which are based on Cold War scenarios.) Though some OOTW models exist; requirements for these mission areas should be developed to meet future needs. For example, models require representations of non-lethal weapons.

- Use of humans and live systems. Whenever an experiment examines decision making, command and control, and the processing of information, then humans and actual or credible representations (for future) of C4ISR systems should be employed. This requirement stems from the immature state of art for representing these processes. When available, data on human decision making and behavior should be collected and used for future constructive representations of human behavior and cognitive processes.

- Use of decision matrix. A decision matrix that uses selection criteria, as described in viewgraph 9, is strongly recommended as an aid for determining the best models and/or simulations for an experiment. Criteria in addition to those described in this report, would address other factors important to model selection.

Joint Experimentation Workshop

Assessment and Utilization of Results Working Group

Assessment and Utilization of Results Working Group

Working Group Participants

• *Jacqueline Henningsen,FS, WG Chair*	*HQ USAF AXOC*
• *Priscilla Glasow, WG Co-Chair*	*MITRE*
• *Linda Weber, WG Co-Chair*	*MITRE, USACOM J97*
• *J.L. Adkinson*	*MCWL (EDO, TSA)*
• *John Baird*	*Raytheon Systems*
• *Robert Fleming*	*Camber Corp.*
• *Christine Fossett, FS*	*GAO*
• *Frank Gross*	*CAI, USACOM J97*
• *Dean Hartley, III*	*Data Systems R&D Prog.*
• *Floyd Kennedy, Jr.*	*Submarine Forces Atlantic*
• *LTC Michael Kwan*	*TRADOC Analysis Center*
• *Ronald Magee*	*TRADOC Analysis Center*
• *Mark Murray*	*HQ TRADOC (Utilization)*
• *CAPT JD Oliver*	*USACOM J97/J98*
• *Randall Schmidt*	*BETAC, AFEO*
• *Richard Simpson (NATO)*	*Allied Command Atlantic*
• *Donald Theune*	*Virtual Technology Corp.*
• *LTC Fletcher Thornton*	*Joint Staff J8*
• *RADM (ret) Gary Wheatley*	*Evidence Based Research*
• *Leland Joe*	*Synthesis, RAND*
• *Jerry Kotchka*	*Synthesis, MORS Past President*
• *Chuck Volmer*	*VII Inc*
• *Lt Gen (ret) Steve Croker, USAF*	*EFX Senior Mentor*

Working group members and their affiliations are shown on this slide.

Composition of the Group (does not include synthesis participation):

10 Government/Military

2 FFRDC

7 Contractors

Functional Composition:

2 United States Air Force

3 United States Army

1 United States Marine Corps

1 Navy/Joint

5 Joint (1 JS, 3 USACOM, 1 Jt Doctrine)

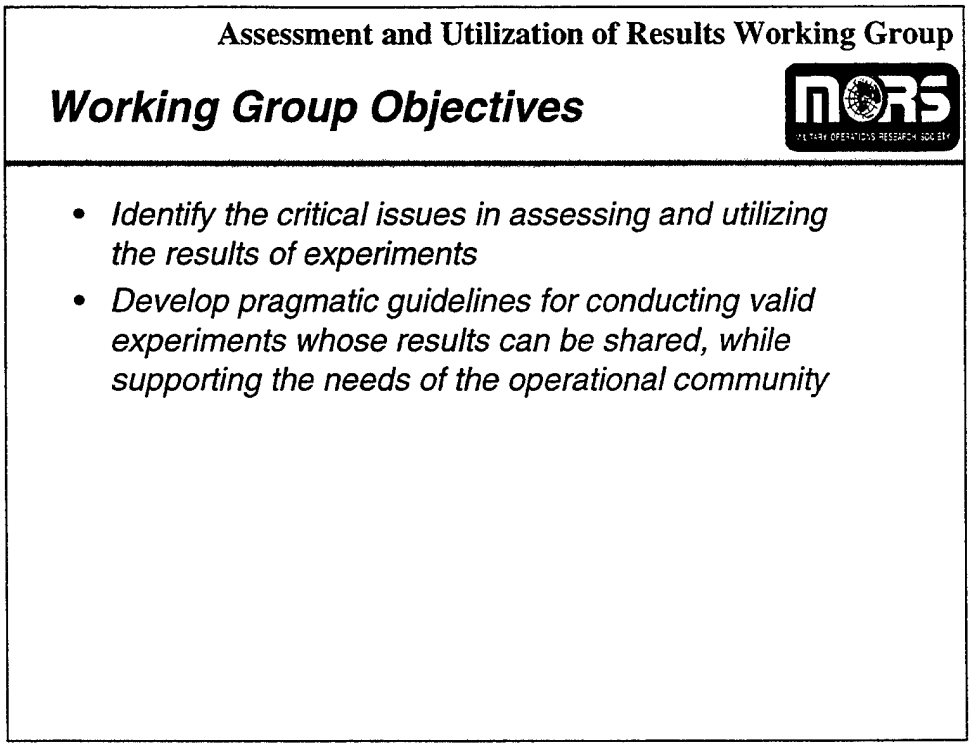
1 Office Secretary of Defense

1 USG (GAO)

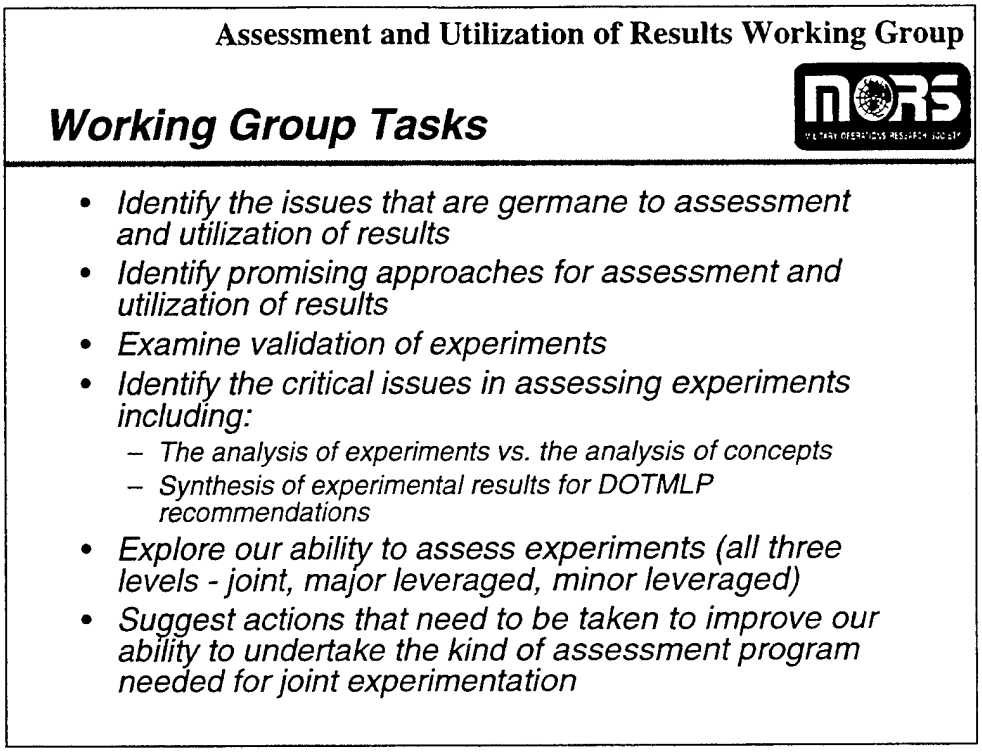
1 DOE

1 NATO

3 Other (2 M&S, 1 AIAA)



The objectives of this working group focused on identifying issues and promising approaches for assessment and utilization of experimental results. We also explored the relationship between validation of M&S and validation of experiments.



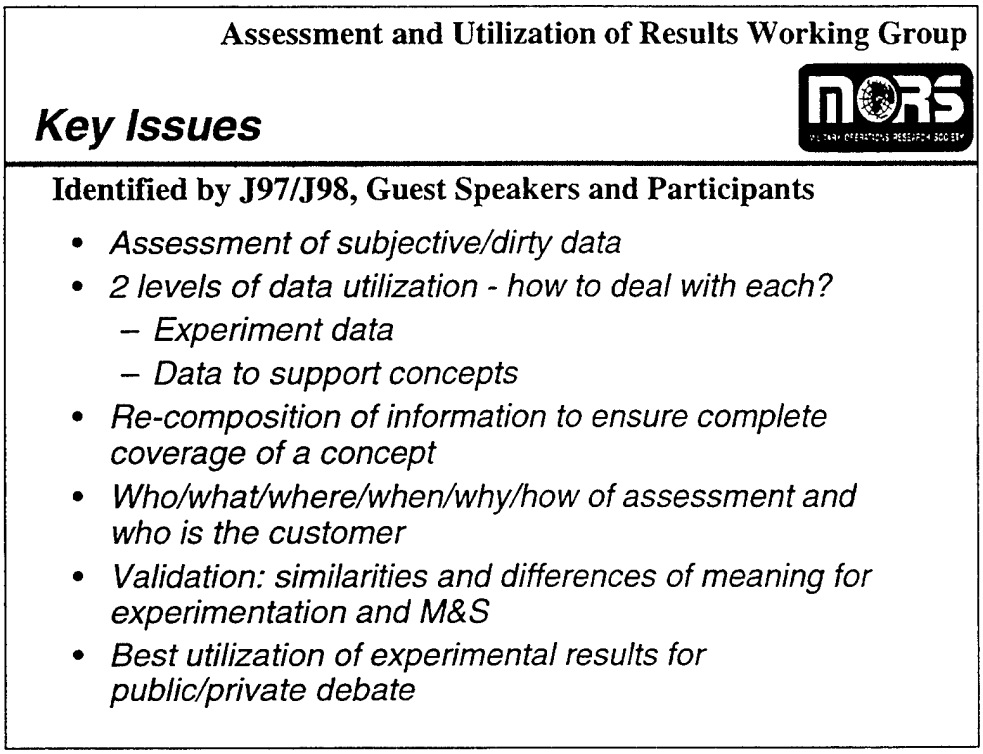
The objectives were further refined by choosing a series of specific tasks from the overall Terms of Reference (TOR) for the meeting and modifying them to fit the working group theme.

Assessment and Utilization of Results Working Group

Agenda of WG Presentations

- *Tues, 9 March*
  - *Introductions - Jacqueline Henningsen, FS*
  - *ACOM overview - CAPT Oliver, J97/J98*
- *Wed, 10 March*
  - *Assessment and experimentation - LtGen (ret) Croker*
  - *Service experimentation*
    - *JCF AWE - LTC Kwan, JCF AWE Assessments*
    - *JEFX - Mr. Schmidt, AF Experimentation Office*
- *Thurs, 11 March*
  - *Validation of results - Priscilla Glasow*
  - *Utilization of results - Mr. Volmer*

Working group time was structured by the use of a limited number of key presentations focused on the objective areas. This included a challenge briefing from CAPT Oliver, J97/98. Lt Gen. (ret) Steve Croaker, USAF, led a seminar and discussion on observations and lessons learned from EFX 98 with broader implications for assessments of experiments. Methods for including assessment in the Army Advanced Warfighting Experiments and the Air Force's next Expeditionary Air Force Experiment were presented and discussed by LTC Kwan of the Army and Mr. Schmidt representing the Air Force. Priscilla Glasow led a discussion of validation as it applies to M&S in comparison to experimentation. Finally, Mr. Volmer explored the utilization of experimental results by external groups such as Congress.



On the first afternoon, Captain J.D. Oliver, J97/98, presented an overview of the J97 Assessment Division and the J98 Integration Division. He identified the following issues for working group discussion:

1) Assessment of subjective/dirty data.
2) Experiment versus conceptual data utilization.
3 Recomposition of information to ensure complete coverage of a concept.

To these baseline issues, the group added the requirement to understand "who, what, where, when, why and how of assessment and who is the customer.

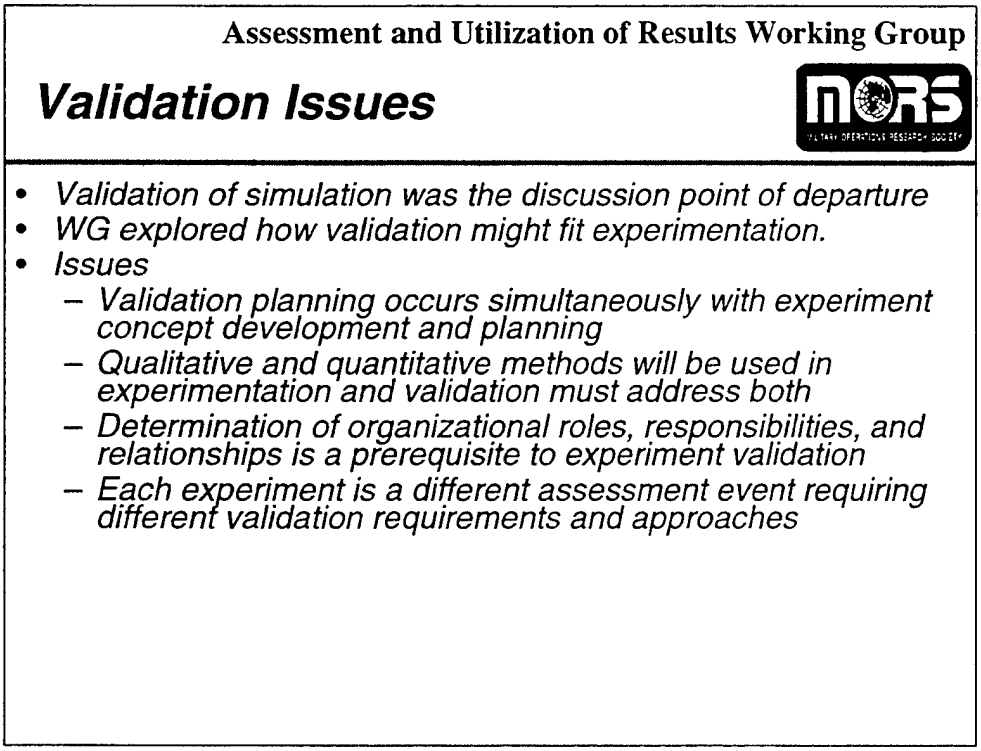
Further progress through the presentations led to concerns about the utilization of experimental results in the public (external to the experimental process) and private (relevant to the experimental purpose.)

Assessment and Utilization of Results Working Group

Assessment Issues

- *Ethical issues in experimentation - what are laws for experimentation with people, do they apply to military?*
- *Managing the media with respect to results*
- *Misconception that assessment is an 'add on' to the experiment*
- *Participants*
  - *Proper Selection Does Matter (Golden Crews, Cat-5 or Rainbow, etc.)*
  - *Inclusion (part of feedback loop; remediate if necessary)*
- *The live event is NOT the experiment; it may not even be necessary*
- *Concept exploration should include many experiments, but experiment may be the universe, part of an exercise, or part of a broader experiment*
  - *How does assessment differ across these? The tasks are similar, but sphere of influence differs*

Additional issues that call for careful consideration are provided on this slide. For instance, members were surprised by the information that regulations may call for careful use of release processes for many simple experimental assessment procedures; such as human factors based surveys. The group noted that many organizations maintain "human subject review teams" and suggested this may need exploration. The concept of effectively managing the media was not intended to have a negative connotation. Rather it emphasized the idea that some aspect of assessment preparation may need to be focused on ensuring that a reasonable process for providing insights and first order observations to the press should be considered. Participants stressed the idea that assessment should not be viewed as an add-on, but treated as a fully integrated part of the experiment. The group spent a lot of time discussing the criticality of properly selecting the participants in an experiment. It is extremely important to know whether the use of uniquely qualified, not-fit for other taskings or cross community teams are best suited to obtaining experimental information. Equally important is an early decision concerning the proposed treatment and involvement of participants. Will they be full partners in the assessment process with transparency in results or will they be shielded from knowledge of outcomes. If a major problem emerges that will greatly reduce the ability of obtaining valuable data, will the experiment be "restarted" or will it move forward at all costs. Again, these are issues that need to be decided for each aspect of a complex experiment. Working group members noted that it is very important to dissuade the view that the live event is the valuable or only real part of the experiment. It is equally important to use the full pre and post period activities as part of the experiment (possibly by the use of simulation). Focusing on the joint experimentation challenge, participants noted that concept exploration will likely be composed of numerous experiments. Therefore, an experiment may be viewed from the perspective of how it fits in the overall campaign or how it is meeting a narrow objective. The assessment process will be structured differently to evaluate the context of the experiment.



Priscilla Glasow's guided discussion on validation led to the identification of the issues listed above. It was viewed as important, but under-appreciated, that validation planning should occur simultaneously with experiment planning. Further, the validation must address both the qualitative and quantitative aspects of the experiment. The former is obviously easier than the latter. It is equally important to understand that validation does not cut across all assessment events in an experiment. It must be tailored to each aspect appropriately.

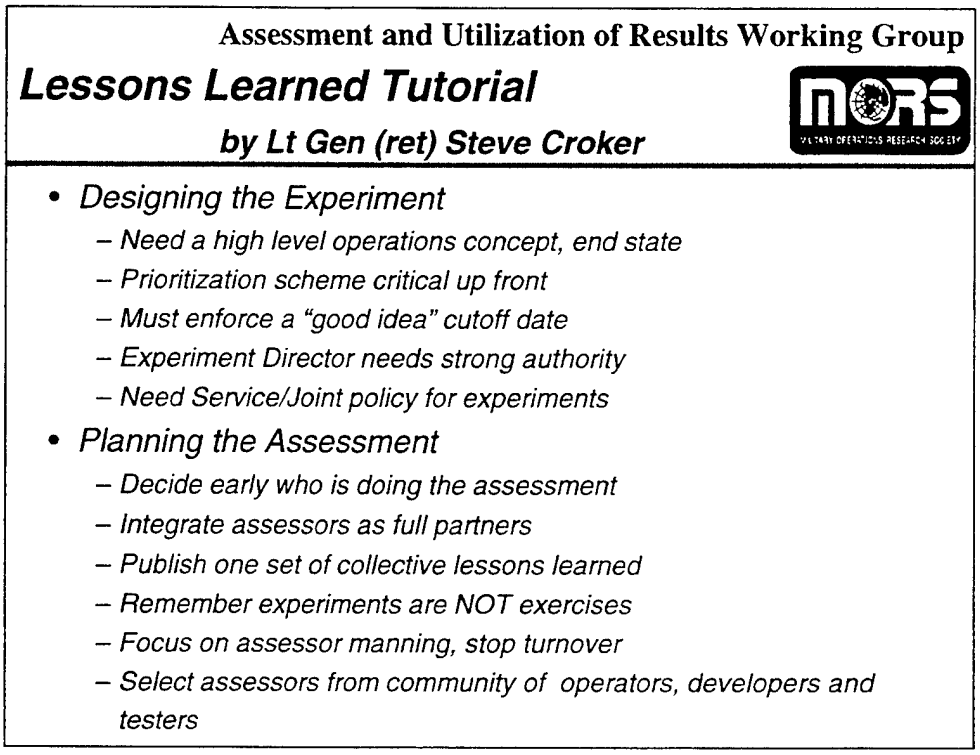
Assessment and Utilization of Results Working Group

Utilization of Results Issues

- *Results published on front page of the Post (w/o approval)*
- *Wrong lessons learned/political filtering*
- *Perishable data/results (timeliness)*
- *Results don't get to users (right levels)*
- *Loss of capture opportunities*
- *Roles and missions (Title 10 Issues)*
- *Failure of experiment to identify all relevant issues (e.g. logistics/information/training)*

- *Service concerns (re: loss of destiny control, loss of control of experiments)*
- *Ownership of data (DoD control and persistence — don't pay for data twice, know where to get data)*

The utilization of results issues focused on the public vice private use of experimental results. The latter is most frequently what the designers, planners and players have in mind, but the former should be given careful attention. Dangers lie not only in early or inaccurate release of results, but equally with the possibility of negative lessons learned. Without proper training in the purpose of an experimental design, participants frequently fall into the "win at all costs" exercise mentality. This can not only lead to poor experimental data gathering, but also to negative learning and disgruntled participants who report their limited perception as truth for the whole experiment. This can also occur when observers see a weakness or "failure." The ability to fail is the mantra of experimentation, but is difficult to communicate as a learning tool. A number of other important considerations in the utilization of results are noted. The presentation by Chuck Volmer highlighted a wide range of additional linkages to areas as broad reaching as the National Security structure debate.



Lt Gen Steve Croker, USAF (ret), who has served as a Senior Mentor for numerous service and joint experimentation, wargaming and exercise events, led a seminar drawn from observations of Expeditionary Air Force Experiment (EFX 98) and other venues to explore lessons learned, key assessment issues, data collection methods and an assessment roadmap. He emphasized that large-scale experimentation is a new, uncertain process and it is essential to allow for failures. EFX 98 validated the promise of experimentation and provided a test bed for evolving the experimentation assessment process. He focused on some significant assessment lessons included the value of using an "enterprise" versus an "independent test" approach to assessment. (He noted that even more fundamental is the importance of clearly communicating to all parties the underlying premise of whatever assessment process will be used).

Assessment and Utilization of Results Working Group

Lessons Learned Tutorial (continued)

by Lt Gen (ret) Steve Croker

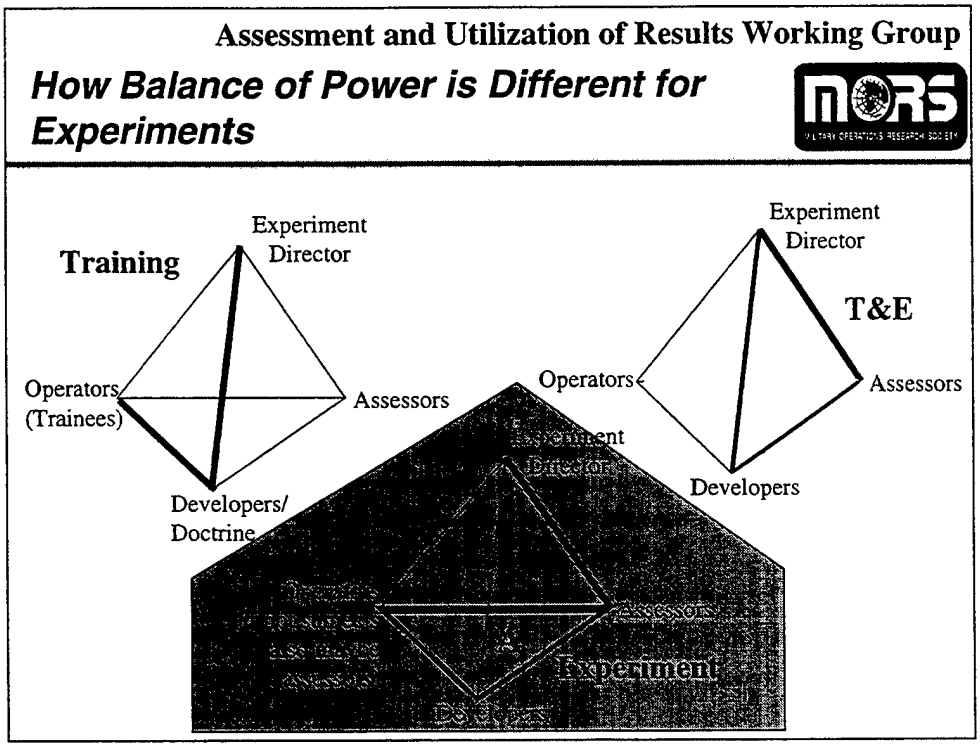
- *Implementing the Assessment*
  - *Keep all assessments under one roof*
  - *10:1 operator to assessor ratio about right*
  - *Rate the experience of the source*
  - *Cross-functional assessment teams work*
  - *Need a simple, manual questionnaire*
  - *Don't forget the key people's judgements*
- *Process Notes*
  - *When assessing tools to be used by all services, use all services equipment*
  - *The ability of M&S to stop/start and provide "instant replays" is key*
  - *Test piece parts before the entire system*
  - *Unless we know where we are going, any road will get us there*

The enterprise approach required that assessors are considered full partners in the experimental process, and are integrated into the experiment from the first step of planning. It is also important to recognize the need for early involvement of M&S, the establishment of prioritization schemes to help distinguish the relative importance of various experimental components, and to realize the difficulty of layering experiments onto exercises. A number of his discussion topics are provided on these slides. Additional insights were included in the full presentation.

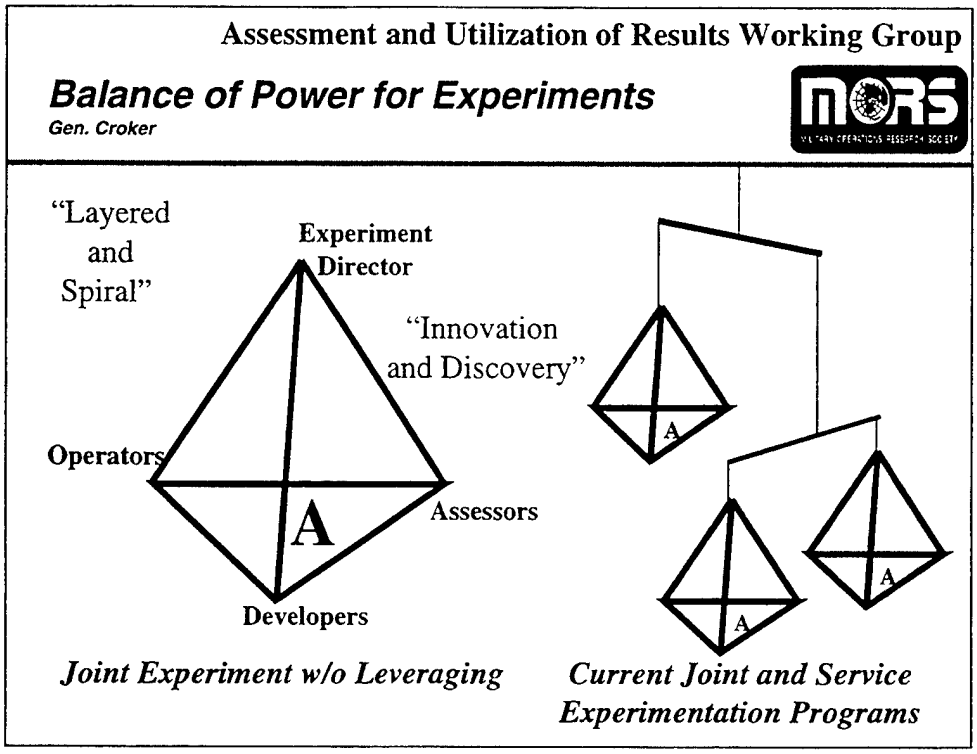
Assessment: Who

- *Team with "strong" lead analyst — "junk yard dog"*
  - *Joint representation (coalition?)*
  - *Multidisciplinary*
  - *Subject-matter expertise*
  - *Analytic expertise*
  - *Data technicians*
- *Evidence of success*
  - *Credible to range of customers*
  - *Team perceived as knowledgeable*
  - *Authority is sufficient to ensure balance between different levels of experiment*

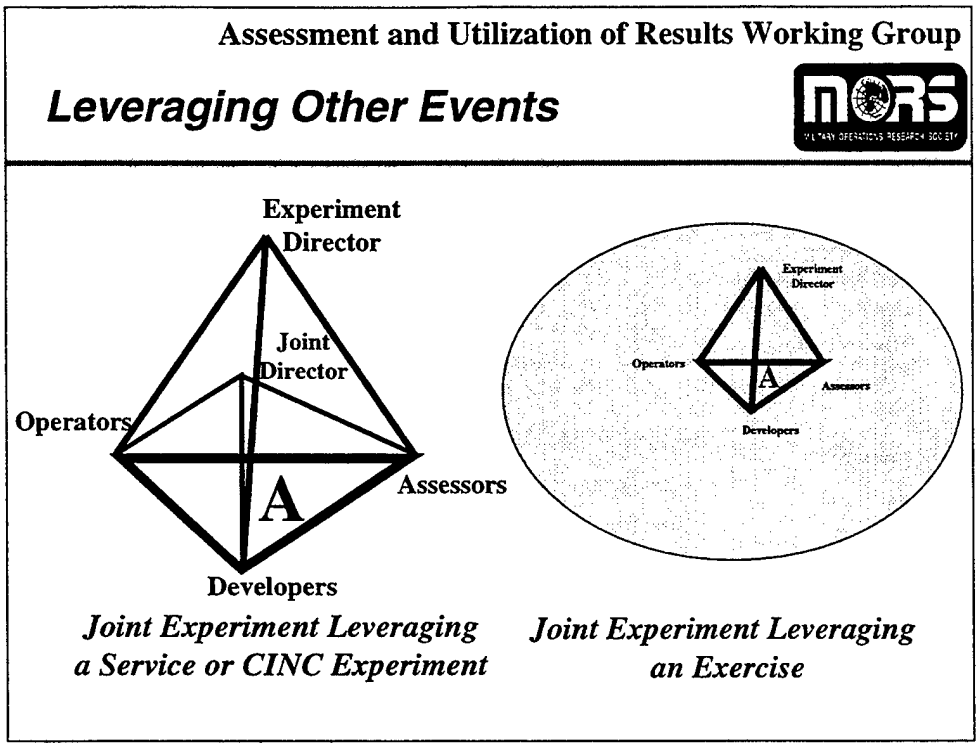
Various aspects of "who" should lead and participate in the assessment team was explored. Participants were amused by one speaker's statement that the leader must have the tenacity of a "junk yard dog" in order to keep the balanced position for assessment. The proper representatives on an assessment team are not uniformly identifiable, but the notes on this page indicate some of the considerations that should be part of the planning process. The Assessment planners may wish to develop a checklist that is reviewed for each "event." A balanced team may need to have a multidisciplinary rainbow coalition of its own (similar to the EFX 98 concept of participants selected from a range of venues). The role of joint and coalition membership on the assessment team vice on an observer team will be closely linked to the objectives of the event. Clearly subject matter expertise is desirable, but there is also the difficult consideration of whether to put the best SME's in player or assessor roles. This tension can be addressed if the assessment is considered a partnership rather than a scored test. The next slide addresses this concept.



The graphic in this slide highlights the concept introduced by Lt Gen Croker and expanded by the working group of carefully distinguishing the *assessor* from the various roles of an Assessor in training, exercise and experimentation venues. The heavy lines show the areas that tend to have greater authority in each venue. Further in considering each case, it is important to understand the relationship between team members. In experimentation, the group hypothesized that assessor (little a) should be an equal partner in a team that includes the operators, and the developers (concept or system). An Assessor (big A) in the traditional experimental sense stands back (with a clipboard) and grades the experiment while minimizing interference. In the case of the assessor (little a), assessment takes place through a cooperative process in which the operators', and when appropriate the developers', observations are captured and prepared for analysis by the assessment team using various data capture mechanisms. In this case, the assessor is a facilitator of information capture and appropriate feedback. The group postulated that there is no true experiment value without integrated assessment.



Continuing the graphic introduced in the previous slide, assessment applies not only to an individual experiment, but also to progress on the overall campaign. In view of the use of spiral experimentation to advance through a series of increasingly complex interactions, the working group coined the term *spiral assessment* to capture the importance of tailoring the assessment process to different stages of experimentation. In the early phases of exploration when systems are just being introduced or concepts being refined, the assessment process should be tightly focused on identifying ways to move the individual aspect along (or identifying its inappropriateness for the experiment.) In the later stages, the assessment should refocus on the interactions, finally in the final stages assessment should focus on the potential of the system of systems and concepts. The term *layered* assessment was introduced to focus attention on the need to provide parallel assessments of the progress of the entire Joint Experimentation campaign, of the specific aspects of various experiments, of the individual aspects of a specific experiment.



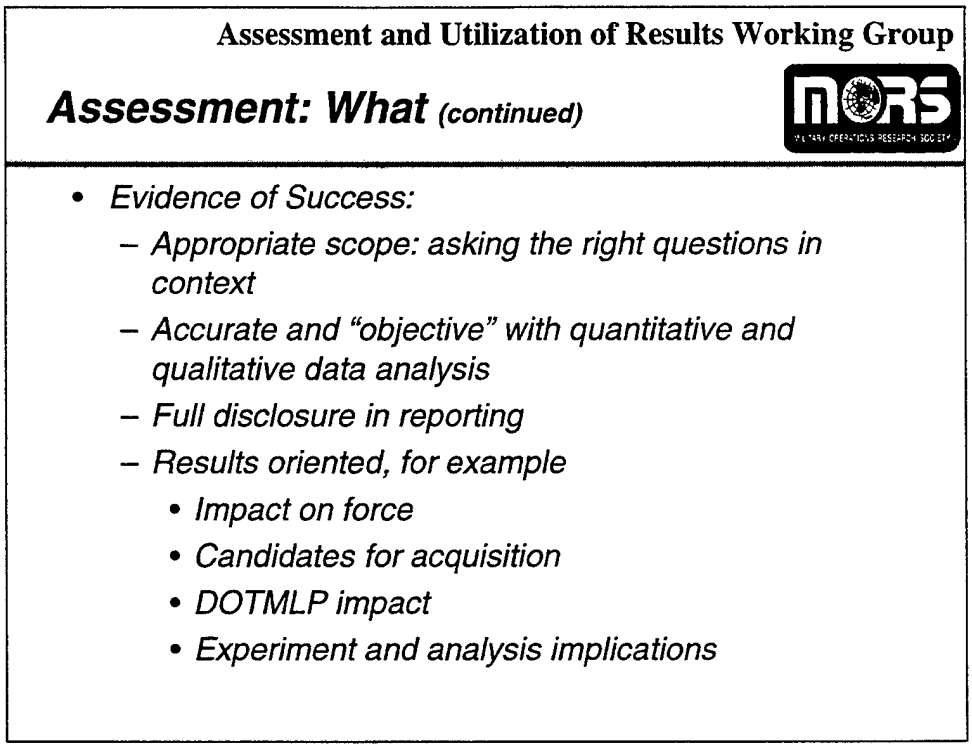
The pyramid charts were used to portray the idea that current programs may tend to be disjoint experiments. This slide highlights the point that there are multiple layers of relationship between different events and the overall JE Campaign. For instance, a joint experiment may be embedded within a service or CINC exercise or experiment. The role of the assessors in this case must clearly indicate a reporting chain and rules of procedure for release of results.

Assessment and Utilization of Results Working Group

Assessment: What

- *Assessment integrated with all phases of experimentation:*
  - *Concept development: evaluability assessment; meta-analysis of past work*
  - *Planning: feasibility assessment*
  - *Design: study design, scenario development and data management plan*
  - *Conduct: adaptable data collection (prepare for unexpected); feedback (modification; rerun...)*
  - *Assessment:*
    - *Post-1: immediate assessment reporting*
    - *Post-2: integrative assessment: synthesis; knowledge management (storage and retrieval for future use) — may require 'iterative reporting'*
  - *Integration: re-composition of information to assess concepts across multiple events*

Assessment must be fully integrated throughout all phases of experimentation including concept development, planning, design, as well as conduct. Assessment is so vital to the outcomes and the resources involved in experiments are so dear, that assessors should be fully integrated into the experimental design, planning, execution and replanning and have representation at the senior level of the oversight process. The working group concluded that aloof independence is not preferred at the level of the actual experiment and that operators and developers are part of the assessment team. There is a need to establish the credibility of the assessment team interface and a strong support for the assessors needs to be established early in the process. This means that Rules of Engagement (RoE) and interaction will need to be carefully defined by a strong assessment team lead who is tightly linked to the Experiment Director (ED).



The group examined various measures of what should be included in assessment. Members were particularly concerned that the assessment process be results oriented. Very rapid feedback concerning progress on objectives has been observed as a standard expectation of senior leadership, and participants as well as observers will freely disseminate their views of success or failure, so a carefully prepared process for reporting various levels of the assessment in a timely manner is critical. If an assessment plan with timed feedback points and level of detail is part of the original plan as well as steps for transitioning the results into future events is prepared during the design and planning phase, there is more likelihood that valuable lessons will not be overlooked. A key point noted time and again was the need to instill at all levels that an EXPERIMENT IS NOT THE SAME AS AN EXERCISE.

Assessment: What (concluded)

- *Issues:*
  - *Assessment tasks are shared responsibility with operators and developers*
  - *Reporting is continuous and corporate/enterprise effort (with assessment lead)*
    - *Initial impressions reporting from rehearsals and training is valid*
    - *Immediate reporting before participants leave a live event ensures 'proper' lessons learned*

Assessment: Where

- *Multi-dimensions of assessment (next slide)*
- *Measures:*
  - *Completeness of assessment by event*
  - *Completeness of assessment by concept*
- *Issues:*
  - *Very complex*
  - *Re-composition of information across events to support concepts*

Measures for assessment need to be developed and responsive to not only the various concepts being explored, but also to the various event types such as joint, major leveraged (usually multi-Service initiated events) and minor leveraged (perhaps a tag on to an individual Service event.) Decisions about the location, distribution, housing, funding, reporting chain and other aspects of the assessment process and team must be made. Experienced group members cautioned against removing the assessors too far from the "heart" of the experiment and the ability to quickly identify and work with the director to resolve emerging problems that would minimize the ability to work on core objectives.

Assessment: When

- *Early and continuous: start with concept*
- *Immediate utility*
- *Cumulative utility*
- *Measures:*
  - *Timely information*
  - *Knowledge repository*
- *Issues:*
  - *Analysts must find ways to be timely without sacrificing quality*

It is worth repeating that assessment must be fully integrated into the experimental design, implementation and review. Both aspects of immediate and cumulative utility must be considered in the design of the assessment process. Measures must account for both the release of timely information sufficient to satisfy early needs for feedback, and the requirements for a more comprehensive knowledge repository that can be used to develop an encompassing picture of progress toward the JE campaign goals. It is critical that the assessors/analysts find ways to be both timely and to maintain quality. The partnership with the whole exercise team must be attuned to fulfilling this critical function.

Assessment: Why

- *Experiment is equivalent to Assessment (analysts' relief act)*
- *Experiment is the...*
  - *Act of attempting an innovative method of operation, especially to assess its feasibility, evaluate its utility or determine its limits.*
  - *Opportunity to observe military phenomena and gather, interpret and act on information.*
- *Without assessment, an experiment is just a demonstration.*

It is easy to come to a conclusion that experimentation is inseparable from assessment (group members joked that an understanding of the absolutely critical role of analysts in this process would lead to renewed appreciation of the role of the analyst). This slide identifies some of the ways that an experiment (in the context of joint experimentation) can be considered. Some of the ways that experimentation success can be measured are the longevity of the findings, the discovery of new ideas and the amount of value added information for decision makers. Some issues include the lack of common definitions which may lead to false expectations, and the inability to separate events (such as exercises) in which failure is unacceptable from experimentation where failure is often the source of the most important lessons.

Assessment: Why (concluded)

- *Measures:*
  - *Longevity*
  - *Discovery, new ideas*
  - *Value added information for decision making*
- *Issues:*
  - *Lack of common definitions (understanding) for experiment and assessment (possibly unrealistic expectations)*

Assessment: How

- *Spiral: iterative process*
- *Methods for deconfliction and determining interaction/integration among concepts required*
- *Tools for data collection, reduction, analysis, synthesis — possible requirement for new tool development to support experimentation*
  - *Models and simulations*
  - *Quantitative and qualitative*
- *Measures of merit: MOP/MOE, EOS, KRA*
- *Open to discovery; expect unexpected; flexible and adaptive*
- *Resources*

Several examples of how to run experiments were examined. Some features that the group felt were valuable to the assessment process included the concept of SPIRAL assessment that was previously described in the pyramid charts. Spiral assessment processes may help work through the need to deconflict and examine the interactions among the concepts that are under review both globally and for a specific experiment. It is possible that new tools for data collection reduction, analysis or synthesis will be required to support the experimentation process, but funding issues are more likely to encourage the use of existing or analyst developed adaptations of existing tools. Still, the assessment process should not be left without the resources to develop critical tools, to bring on board appropriate experts or to maintain continuity of involvement with experienced team members.

Assessment: How (concluded)

- *Measures:*
  - *Useful information*
- *Issues:*
  - *Assessment mis-perceived as add-on to an experiment — must have integration from 'day one'*
  - *Subjective/dirty data methods (USAF methods depicted on following 3 slides)*

Assessment: Customers

- *Direct:*
  - *JROC/CJCS*
  - *OSD*
  - *Services*
  - *CINC Commanders*
  - *Participants*
- *Indirect:*
  - *Congress*
  - *Agencies*
  - *Industry*

The idea that there are both direct and indirect customers for experimentation is an essential understanding for the assessment planning process. If the assessment is not developed in a way to address both requirements, then contradictory information may emerge. The measures for the "prime" customer may differ from the measures needed for a public affairs presentation. The JE leadership must determine early in the process what the relationship will be between the various members of the team in terms of use, release and interpretation of information. The analyst usually prefers to keep a distance from this aspect of use of information, but it is valuable to note that an information void will be filled by pieces of information expanded to fill holes. Once a perception is formed, it is often difficult to show its weakness with later arriving information. This aspect of assessment was further explored in the section on use of results.

Assessment: Customers (concluded)

- *Measures:*
  - *Satisfaction by prime customer*
    - *Does not equate to 'liking the results'*
  - *Use of knowledge gained*
- *Issues:*
  - *Differing (conflicting?) expectations (uses)*
  - *Mis-use of results by customer or for unintended customers*

Assessment and Utilization of Results Working Group

Validation of Experiments

- *Concerns*
  - *Need to maintain focus on the analytical purpose of the experiment and validate/assess against that purpose.*
  - *Models and simulations embedded for use within an experiment must be verified, validated and accredited for that intended use.*
- *Recommendations*
  - *OR organizations that support experimentation might offer refresher training in the use of qualitative methods and how to validate and integrate qualitative data with quantitative results.*
  - *Definition of validation concepts as they apply to experimentation is needed and may benefit from a follow-on MORS workshop.*

Priscilla Glasow of the Mitre Corporation, who is an expert on DoD Modeling and Simulation Verification, Validation and Accreditation, led the group in an exploration of the similarities and differences between M&S and experiment validation. Participants focused on the use of analytic tools and models, the producing of "actionable" information and the fact that both offer the opportunity to empirically observe military phenomena. Differences include the fact that simulation examines potential effects; experimentation examines actual effects; and simulation applications are carefully constructed processes that are used to test hypotheses. In contrast, experimentation (as defined by Worley) is a heuristic approach that employs trial and error to support discovery. Some specific concerns and recommendations are shown on this slide.

Assessment and Utilization of Results Working Group

Utilization of Results

- *Invest/divest (revise - fine tune investment strategy)*
- *Evolve DOTMLP recommendations*
- *Document the analytical underpinning of results*
- *Marketing (pro/con)*
- *Guide industry partners/R&D*

Chuck Volmer, VII Inc, presented a thought provoking discussion on the utilization of experimental results to the working group. He started with the hypothesis that "DoD's ORSA/Experimentation process may lack management and administrative checks and balances to avoid intentional or unintentional manipulation or misuse of analytical results." He noted that experiments run the gamut from studies to live fire demos. Mr. Volmer discussed the distinctions between the private (internal to DoD, a service or a sector) and the private national security debates. He noted that joint experimentation as a part of national security public debate has been offered as a big part of the solution to arriving at the answers as well as a catalyst for transformation (by the National Defense Panel (NDP)). He concluded that DoD's path to 2025 will depend largely on the integrity and discipline of the ORSA and Experimentation process. A sample of some of the detailed information covered in this presentation includes: an overview of the over 125 "experiments" a year conducted by DoD, a matrix for managing complex change, an examination of some of the challenges to organizational change and a call for a single strategic framework to integrate studies, wargames/seminars, exercises and experimentation. His suggestions for utilization of experimental results are found on slide 33, but it is recommended that the full presentation be examined by those who are interested in a broader understanding of this important aspect of experimentation.

Utilization of Results (concluded)

- *Identify discoveries and insights for further exploration*
- *Next event planning*
- *Refine experiment methods*
- *Ensure results become part of the DoD permanent body of knowledge*
- *Exploit LHF*

(Low Hanging Fruit)

DoD Conducts Over 125 Experiments per Year

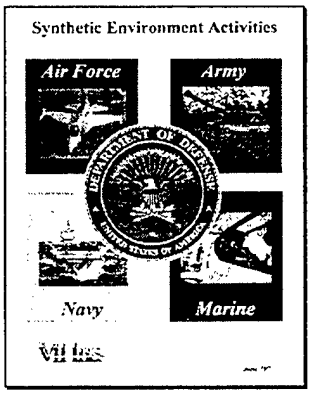
375 DoD Events (FY97-99):

- Studies and Analyses
- Wargames
- Modeling and Simulation
- Exercises
- Advanced Concept Technology Demonstrations
- Battle Laboratories

Organization (Emphasis)

- 153 Army Events (Modeling and Simulation)
- 120 Joint Events (Decision Support)
- 71 Air Force Events (Studies and Analyses)
- 20 Marine Corps Events (Live Demos)
- 11 Navy Events (Wargames)

VII Study & Database

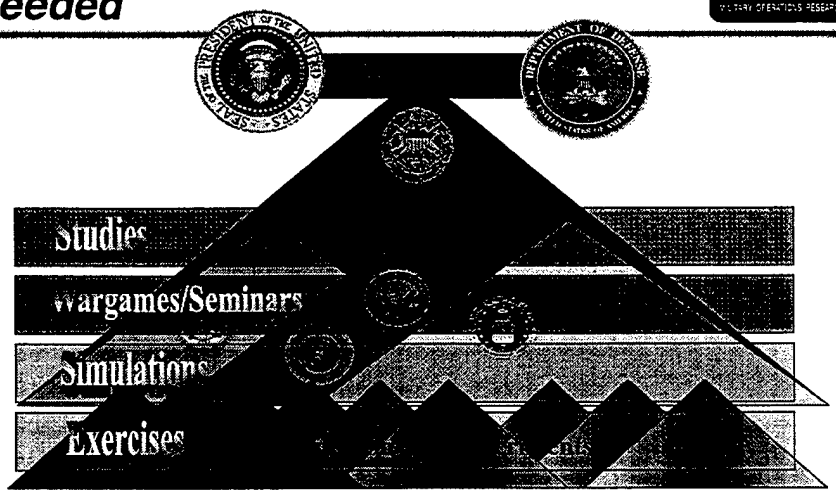


DoD Needs To Avoid "Synthetic Environment Overload" As We Collectively Approach Major Policy Milestones

VII, Inc
Volmer

Assessment and Utilization of Results Working Group

A Single Strategic Framework Is Needed



A DoD Oversight Group Might Be Beneficial For Assessment, Validation, Integration And Adjudication Of Joint and Inter-Department/Agency Experiment Results

Assessment and Utilization of Results Working Group

Focus On Both Public And Private Debates

Current DoD Emphasis

Private Debate

- Battle-of-the-bullets
- Near-term outlook
- Operations driven
- Airpower speak
- Service focus
- System orientation
- Emphasis
  - "Shooters"
  - "Sensors"
  - "Movers"

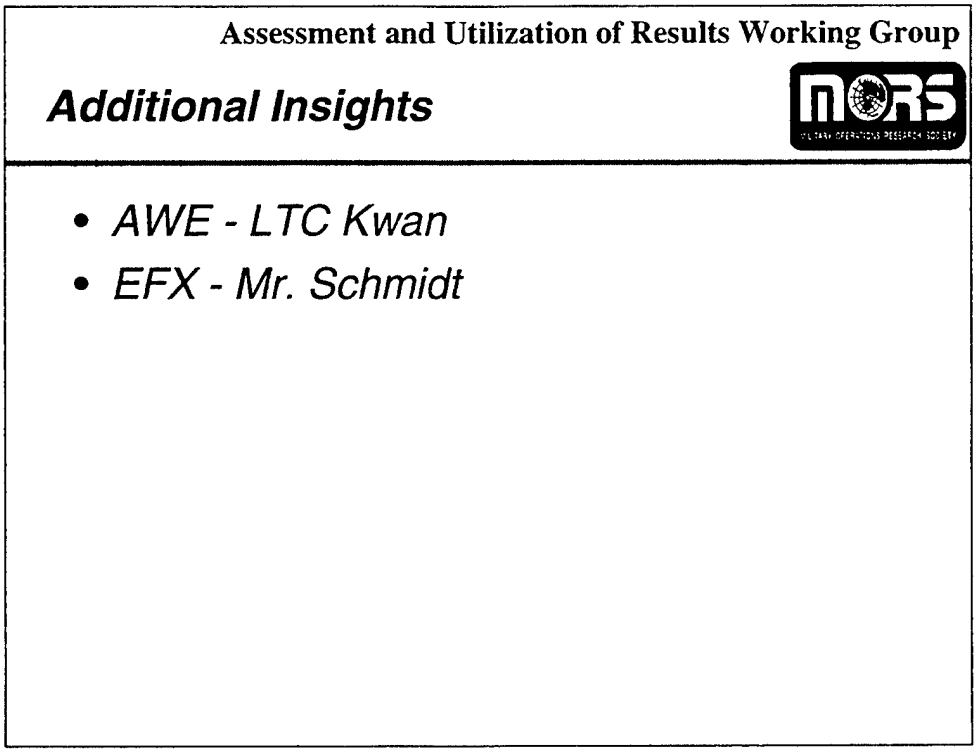
Public Debate

- Battle-of-the-budget
- Far-term outlook
- Policy driven
- Joint/land/Washington speak
- Joint focus
- System-of-systems orientation
- Emphasis
  - "Sensors"
  - "Movers"
  - "Shooters"

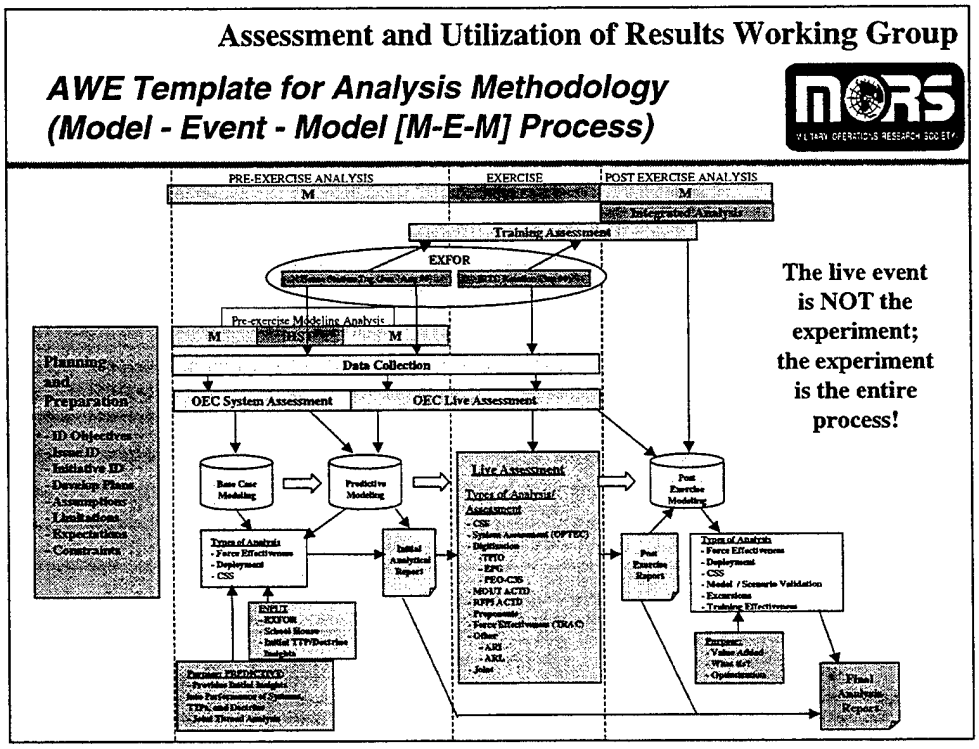
Results Of DoD Experiments Are Often Misused In The Public Debate

Suggestions

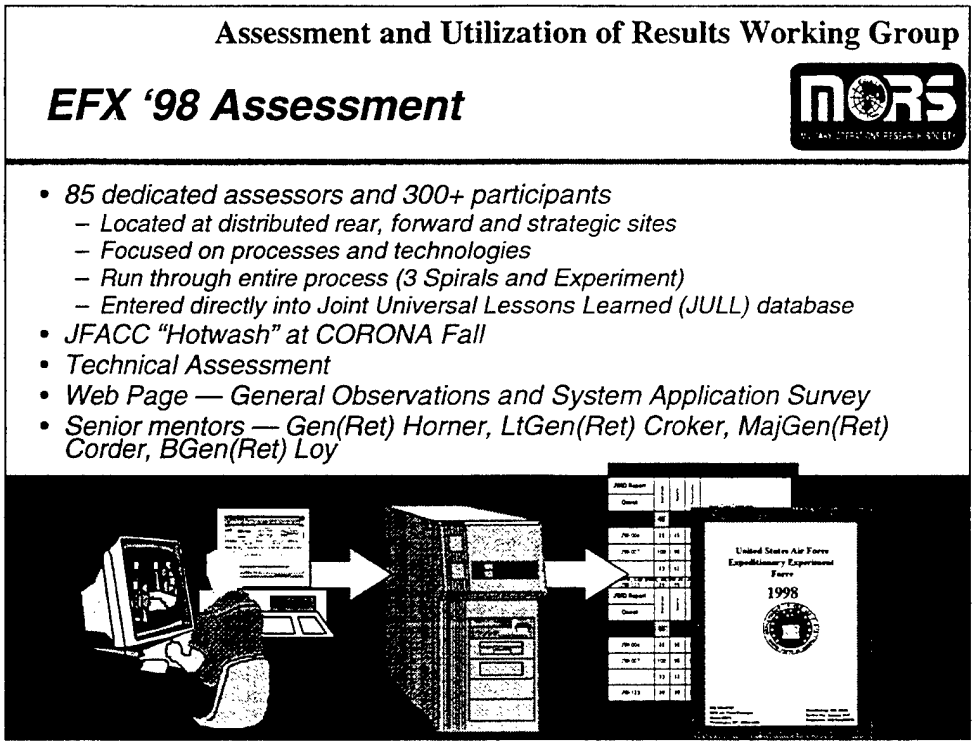
- *Create an overall strategic framework for joint experimentation and inter-department/agency experimentation (and perhaps intra-department experimentation)*
- *Create an oversight group (other than ACOM) to assess, validate, integrate and adjudicate potential conflicts before they are aired in the public debate process*
- *Implement quickly (milestones will soon be upon us) but take a long-term view*



In the words of Lt Gen Croker, experimentation (and especially large-scale experimentation) are essential to transform the DoD into a relevant, capable 21st Century force. Experimentation IS A VALID CONCEPT, and can save lots of money and time...IF... there is the proper assessment and validation of results (so it is not just a demonstration). Experimentation is also a new and uncertain method where all the best practices have not yet been captured and catalogued. Assessment of experimentation is equally new and uncertain, where all the best practices have not yet been captured and catalogued. So a certain tolerance for failure is critical. But to date, the promise held out where experimentation is properly supported by integrated assessment is considerable.



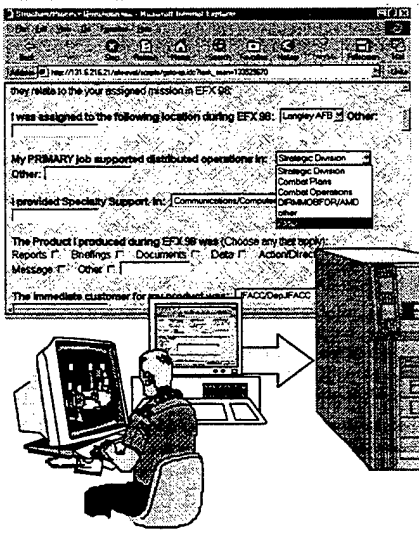
LTC Michael Kwan described the Army Advanced Warfighting Experiment (AWE) process. AWE's were characterized as finding ways to accelerate change, stimulate thinking, leverage judgements of commanders and soldiers to "change the way [the Army] changes." AWE's are intended to reach across doctrine, training, leader development, organization, materiel and soldier support. The focus on model-exercise-model was of great interest to participants. This process starts with scenario and issue analysis used to predict the outcomes of live simulations. The actual outcomes of live simulation are then used to validate and expand "what if" analysis. The live simulation phase is used to focus on data collection, but is also frequently enhanced with simulations/stimulations. Four recommended parallel steps to prepare for a successful AWE were to select and train the experimental force, the opposing force, the observer/controllers and data collectors and (educate) DoD/service senior officials and decision makers. In particular, he provided thoughts on the Joint Contingency Force Advanced Warfighting Experiment (JCFAWE). He explained the template for the analysis methodology that outlines the model-exercise-model process, its relation to the experimentation process and a strawman analysis approach. He stressed the importance of the pre- and post exercise period in which simulation and modeling is used to evaluate a broad range of alternatives that are impossible to examine within a constrained exercise venue.



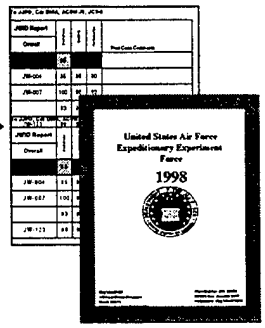
Mr. Randy Schmidt, BETAC, who supports the Air Force Experimentation Office (AFEO) provided additional insights on the Air Force's EFX process. He stressed the importance of the spiral development process and noted that the experiment mantra should be "input, share and analyze." He explained an evolving web technology procedure for gathering experiment lessons learned with links to the Joint Universal Lessons Learned System. He noted that assessment must allow extension of the hypothesis structure from "if – then" to "if – then – so what."

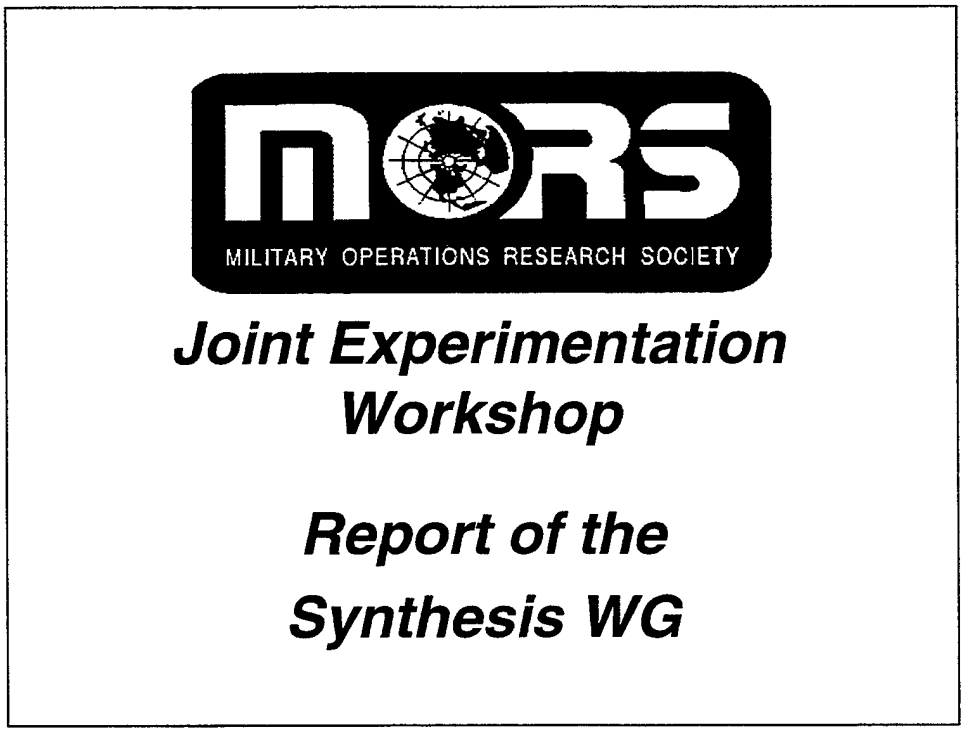
Assessment and Utilization of Results Working Group

JEFX'99 Data Collection Process

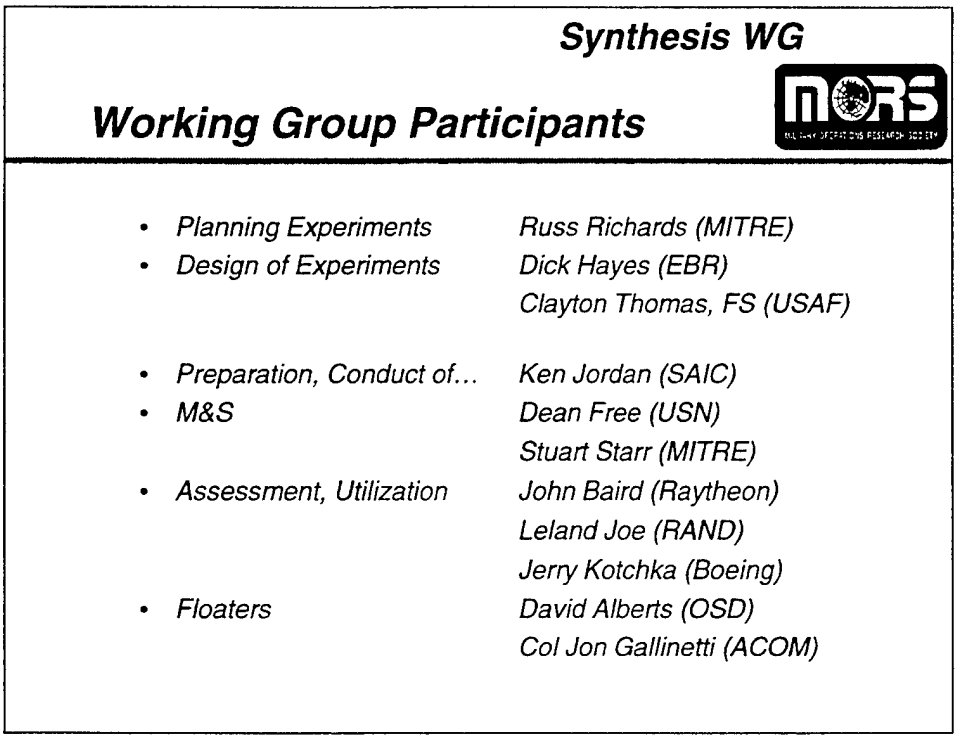


- Standardized queries on web
- Rapid data analysis
- Feeding DoD lessons learned database system



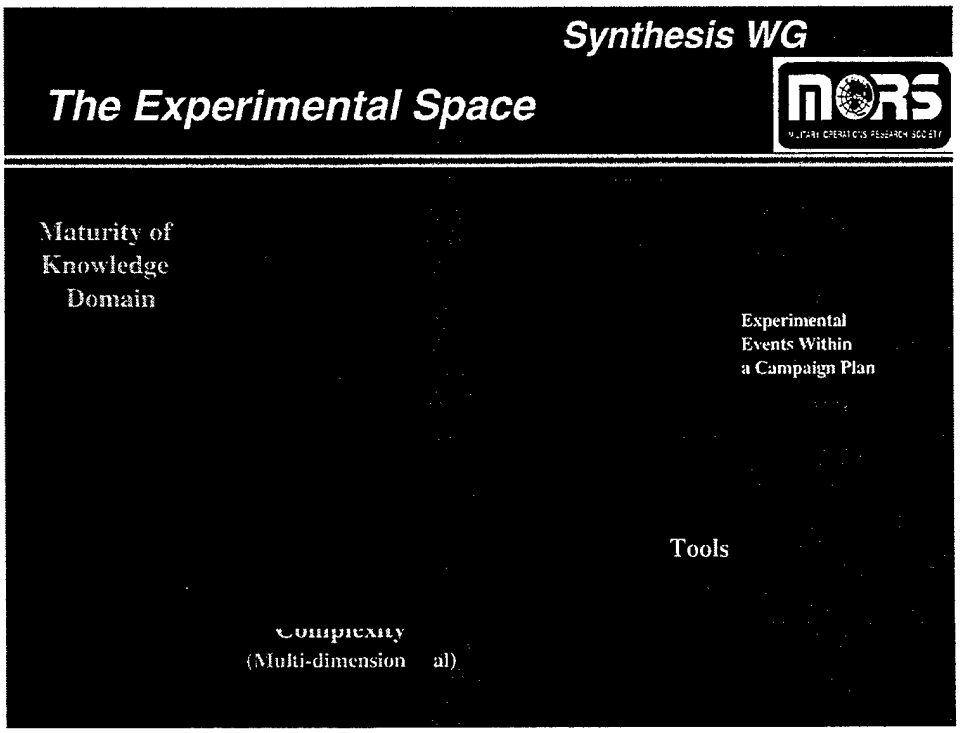


This presentation provides the highlights from the deliberations of the Synthesis Working Group. As a context for those highlights, a business process re-engineering framework is introduced. Using that framework, the report focuses on six key areas: culture, organization, people, processes, resources and tools/data. For each area, key findings and recommendations are provided. The report concludes with some overall observations on joint experimentation.



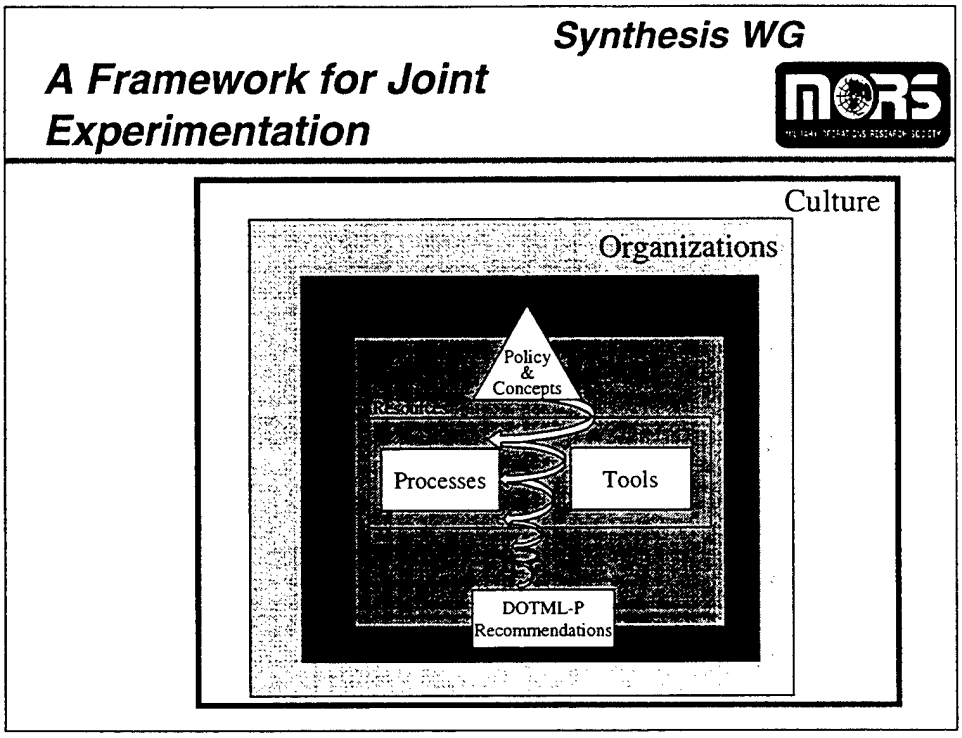
The accompanying vugraph identifies the individuals that participated on the Synthesis Working Group. It can be seen that the participants brought a wide variety of perspectives to bear on the problem (i.e., joint and individual Service; industrial; FFRDC).

Each individual on the working group had two assignments. As their "Day Job," they participated on the individual working groups cited above. As their "Night Job," they had two tasks. First, they helped synthesize selected findings and recommendations of the individual working groups into a "meta-story." Second, they provided independent, value-added findings and conclusions to this synthesis report.



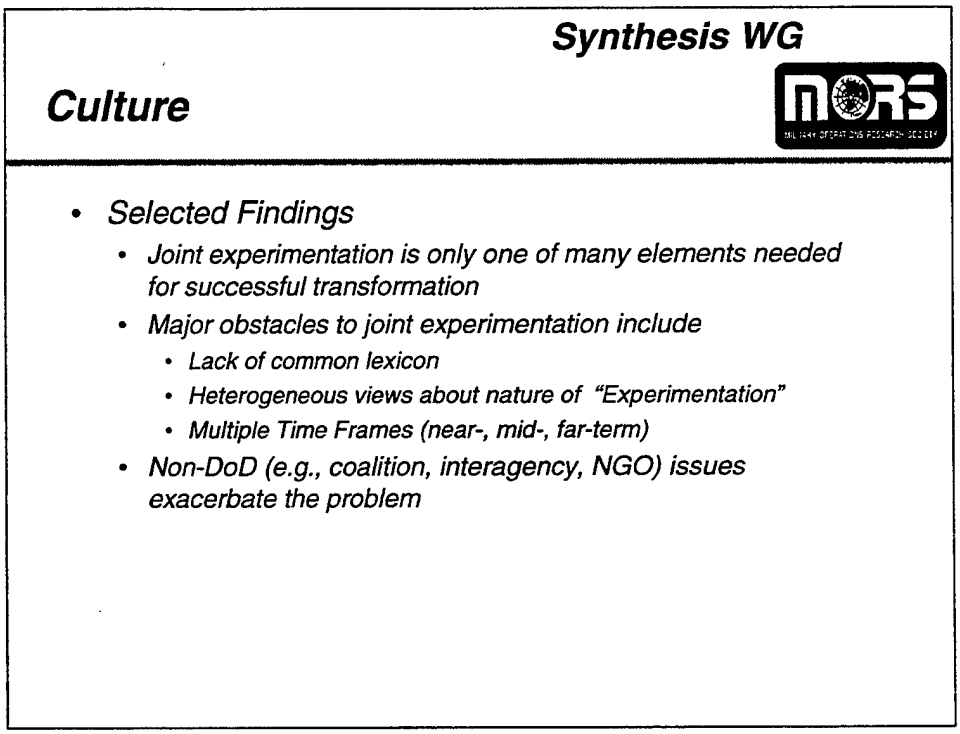
To provide a context for their discussions, the Synthesis Working Group adopted the above model of the experimental space. The space is defined by three dimensions:

- ***The maturity of knowledge domain***. At the outset of an experimental campaign, it is presumed that relatively little is known about the new operational concept of interest (e.g., great uncertainty about the potential effectiveness of the concept over a broad range of potential scenarios). By the conclusion of the experimental campaign, it is anticipated that senior decision makers will have extensive knowledge about the effectiveness of the proposed concept and an in-depth appreciation of its impact on Doctrine, Organizations, Training, Materiel, Leadership and Personnel (DOTML-P).
- ***Complexity***. There are many dimensions that characterize the complexity of the candidate concepts of operations. These include, *inter alia,* the numbers of echelons involved, the information flow, the numbers of actors and their interactions. As suggested by the figure, it would be prudent to begin the experimental campaign by conducting experimental events that are limited to simplified aspects of the concept before addressing the full set of complicating factors.
- ***Tools***. Experimenters have a broad range of potential tools at their disposal ranging from low fidelity (e.g., expert elicitation, system dynamics models) to high fidelity (e.g., live experiments in complex operational environments). As suggested by the figure, the lower fidelity tools should be used to develop a broad, initial understanding of the proposed concept, with tools of greater fidelity employed selectively to gain greater maturity of knowledge.



The accompanying figure provides a business process re-engineering perspective of the joint experimentation enterprise. The Synthesis Working Group concluded that if joint experimentation is to be successful, it must address *all* of these factors, consistently.

As a back drop to the effort, consideration must be given to the cultural changes that are a necessary prerequisite to effective transformation of the military enterprise. Second, there are several organizational issues that must be addressed. These involve both the organization of the teams charged with performing experiments and the ACOM J9 staff. Third, the people involved in all phases of the experiment constitute a critical intellectual resource. Attention must be paid to their education and training to prepare them to participate in the experimentation process. The inner segment of the framework provides the linkage between high level guidance to the experimental process (e.g., policy and concepts) and the primary products of that process (i.e., DOTML-P recommendations). To implement this linkage, a "spiral" set of actions is envisaged which sequentially performs a set of experimental processes supported by a broad set of tools. The figure emphasizes that these experimental processes and tools are constrained by available resources (e.g., funds, manpower, systems). The remainder of this report summarizes major findings and recommendations for selected elements of this framework.



Selected Findings. The Synthesis Working Group found that joint experimentation is not an end unto itself. It is only one of many elements that is needed to transform the military enterprise successfully. As an illustration of some of the other critical steps that must be undertaken in concert with joint experimentation, Reference 1 cites nineteen activities (one of which is "analysis, test, simulation, feedback (early; repetitive) and lessons learned") aggregated into the categories of Concepts and Analyses; Organization and People; Management and Direction; and Resources and Technology.

There are several major cultural obstacles that must be overcome if the joint experimentation segment of the transformation is to be executed effectively and efficiently. First, it was made apparent during the workshop that the service and joint experimentation communities frequently use key terms (e.g., "experimentation") inconsistently. Second, these communities have heterogeneous views about the nature of experimentation (e.g., whether they are on "voyages of discovery," confirming proposed hypotheses, a phase of the "system-of-systems" acquisition process or demonstrating a result). Finally, it was observed that confusion is introduced by the different time frames of interest (e.g., near-term explorations of variations on operational concepts, vice far-term efforts to assess basic transformations of the military establishment).

Synthesis WG

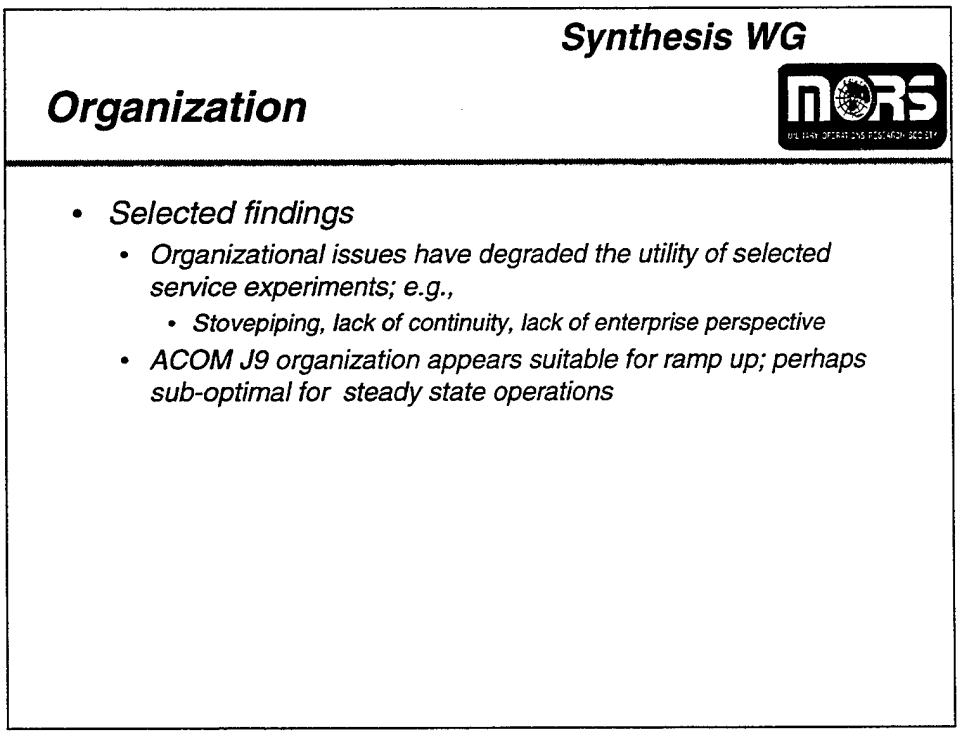
Culture (Concluded)

- *Selected findings*
  - *Joint experimentation is only one of many elements needed for successful transformation*
  - *Major obstacles to joint experimentation include*
    - *Lack of common lexicon*
    - *Heterogeneous views about nature of "experimentation"*
    - *Multiple time frames (near-, mid-, far-term)*
  - *Non-DoD (e.g., coalition, interagency, NGO) issues exacerbate the problem*
- *Conclusions*
  - *A common lexicon must be developed for*
    - *Basic terms*
    - *Key mission areas*
  - *Cultural issues must be addressed at the leadership level*

It was further observed that future experimentation efforts will pose still more profound cultural changes. As experimentation begins to turn towards the issues associated with "New World Disorder" missions (e.g., peacemaking), a host of new participants will be involved. These will include coalition partners, interagency participants (e.g., the Department of Justice in the problem of critical infrastructure protection) and nongovernmental organizations (e.g., Red Cross, in support of humanitarian assistance). These additional perspectives will introduce challenges that will make it more difficult to execute all phases of an experimental campaign.

Conclusions. As an initial step towards ameliorating these cultural issues, a common lexicon must be developed for the basic terms used to describe experiments and experimental campaigns. In addition, this lexicon should define the key mission areas that are the subject of joint experimentation efforts. MORS is well positioned to take a major role in these endeavors.

Ultimately, it is the leadership level that must take the lead in effecting the many cultural changes that are required if successful experimentation is to result in successful transformation of the military enterprise.



Selected findings. There are two important facets of the organizational dimension to the experimentation problem. First, it was noted that organizational issues have degraded the utility of selected service experiments. For example, in several service experiments there has been a lack of continuity of key personnel as the experimental campaign progressed. Those personnel discontinuities have adversely affected the experimental learning curve. In addition, service "stovepipes" have limited the transference of "lessons recorded" in one service experimentation activity to another. As an example, during the Army's Task Force XXI experiments, certain lessons were recorded that were briefed to the USAF's Expeditionary Forces Experiment (EFX) (e.g., limit the number of new initiatives; allow adequate time for training experimental personnel; enforce a "good idea cut-off date"). However, there is little evidence that these lessons recorded were truly learned and acted upon.

The second facet of the organizational dimension deals with the organization of the ACOM J9 staff. Currently, that staff has adopted an organization that reflects the individual phases of the experimentation process (i.e., planning, design, preparation, conduct, assessments,...). The Synthesis Working Group observed that this organization of the staff was probably suitable for the initial ramp up phase of J9. However, it was observed that as the process transitions into "steady state" (i.e., ACOM pursues several experimental initiatives, in parallel), it may prove desirable to transition to a matrix organization where life cycle responsibility for selected experimental themes are vested in a single entity with support from cells of specialized expertise.

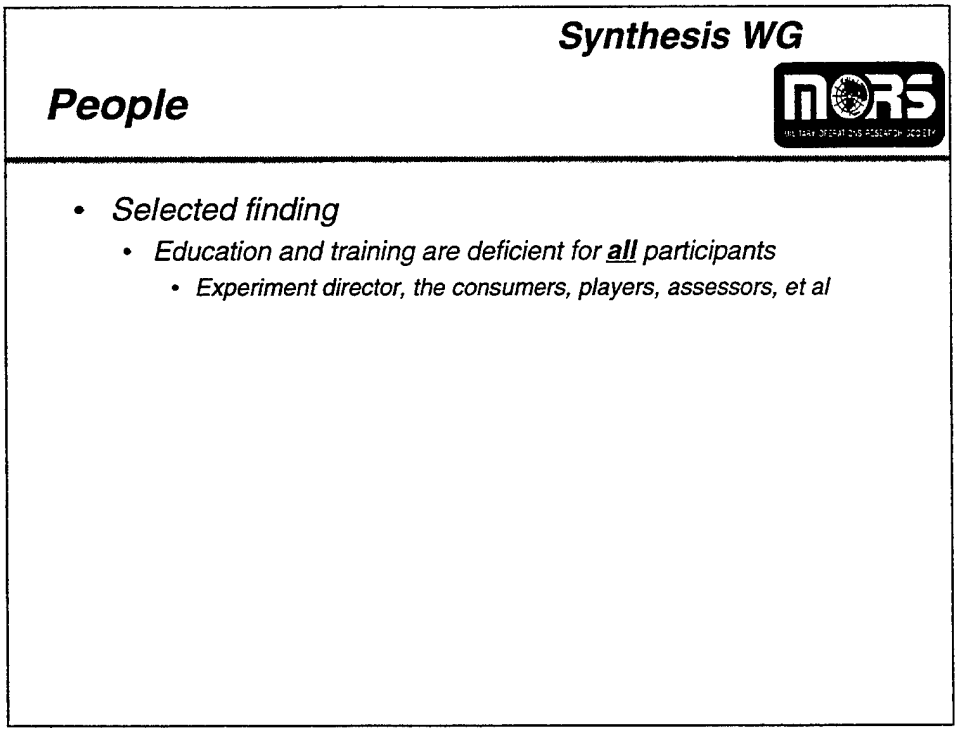
Synthesis WG

Organization (Concluded)

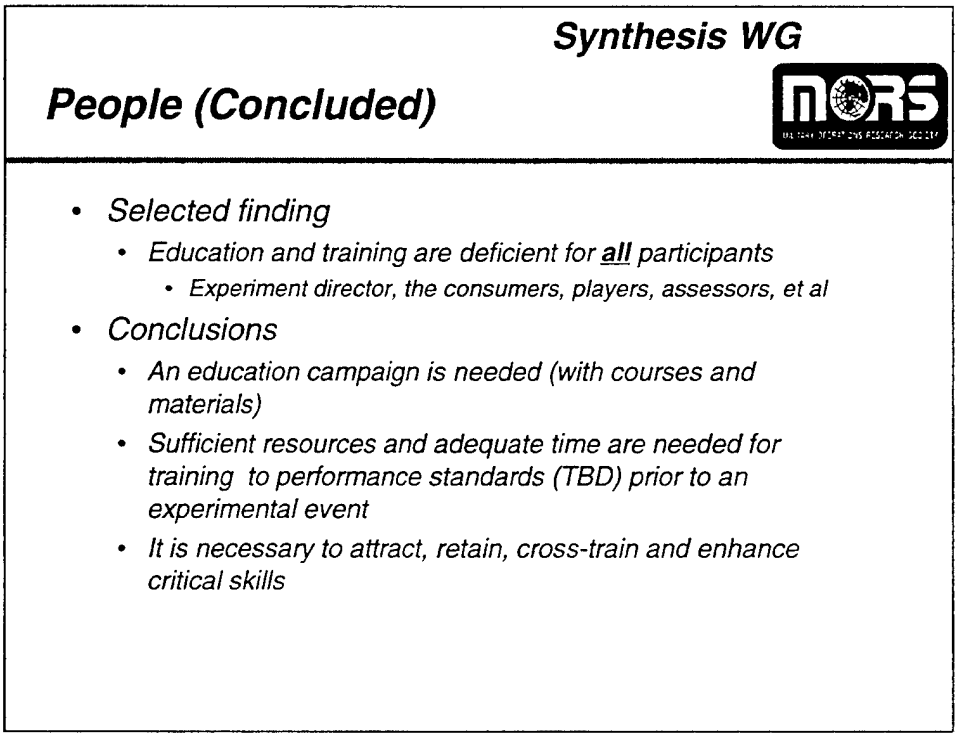
- *Selected findings*
  - *Organizational issues have degraded the utility of selected service experiments; e.g.,*
    - *Stovepiping, lack of continuity, lack of enterprise perspective*
  - *ACOM J9 organization appears suitable for ramp up; perhaps sub-optimal for steady state operations*
- *Conclusions*
  - *A focal point (e.g., ACOM J9) is needed to*
    - *Collect organizational "lessons recorded" in service experiments*
    - *Distill them into lessons learned*
    - *Facilitate their application*
  - *Re-evaluation of ACOM J9 organizational structure is needed to ensure "cradle-to-grave" continuity (e.g., consider matrix organization)*

Conclusions. To address the issues that emerge from organizational stovepipes, a focal point is needed to collect organizational "lessons recorded" in service experiments, distill them into "lessons learned," and facilitate their application to other joint or service experiments. ACOM J9 is uniquely positioned to play this role.

Finally, as noted above, the benefits and costs of a modified ACOM J9 should be evaluated in which "cradle-to-grave" experimental continuity is vested in an organizational unit with matrixed support for selected, in-depth technical support.



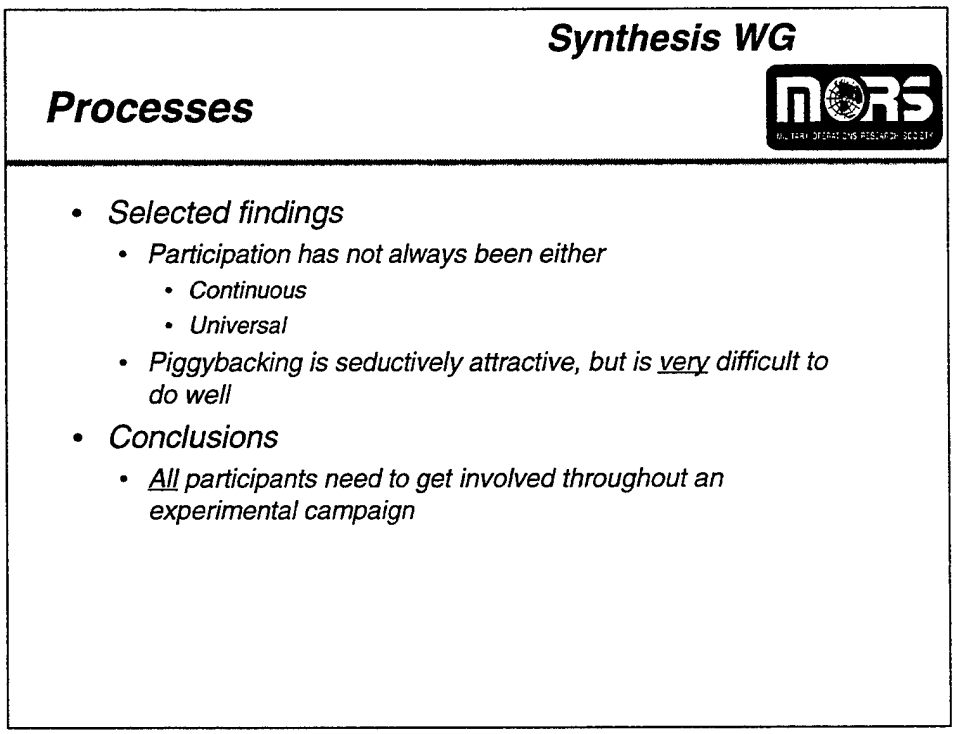
Selected Findings. Several presentations at the workshop revealed that, in initial service experiments, education and training have been deficient for **all** participants in experiments. It was emphasized that this deficiency has adversely affected experimentation performance at all levels. (i.e., from the experimental director through the data collectors/assessors). One of the reasons for this shortfall is the inevitable "time crunch" that is the result of "success-oriented" planning of experiments. Time for education and training is generally the first casualty. As a consequence, it is not unusual for the players to be inadequately conversant with concepts and processes when the experiment begins. The resulting "on-the-experiment" learning, inevitably confounds the results of the experiment.



Conclusion. To deal with this critical issue, an education campaign is needed to prepare all participants in the experimental process. MORS could play a significant role in this process by developing suitable courses and materials and delivering them in conjunction with the annual symposium.

In the future, sufficient resources and adequate time for training must be planned (and protected!) prior to an experimental event. It is recommended that the criterion for training be satisfaction of specified performance standards vice time allocated to training (i.e., use of an output measure versus an input measure).

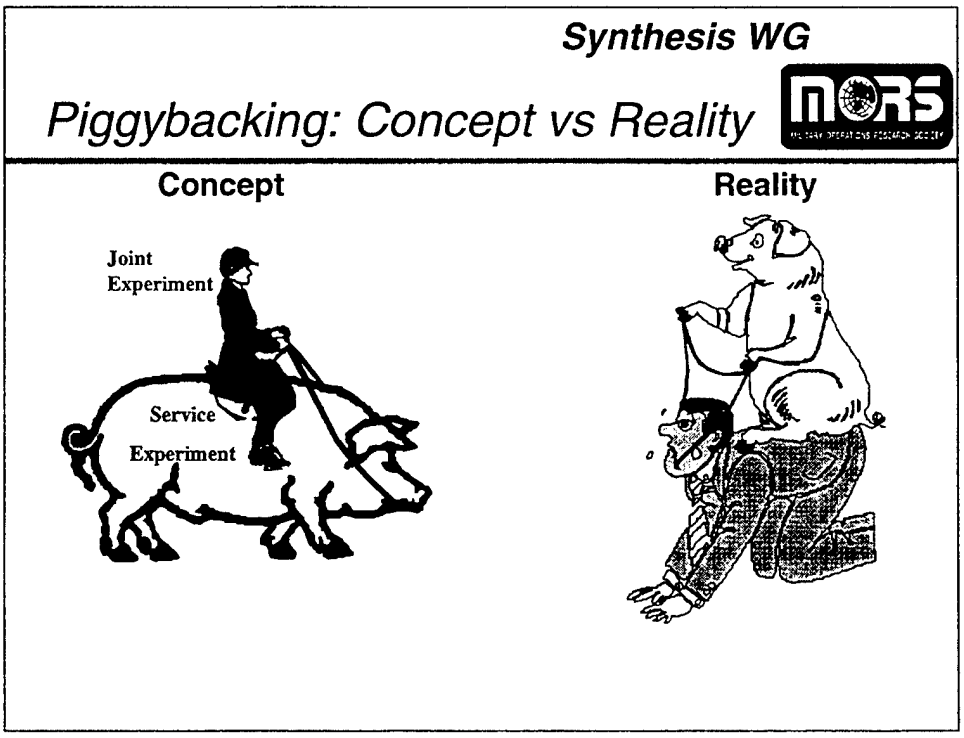
Finally, it is recommended that exceptional steps be taken to attract, retain, cross-train and enhance the critical skills needed to execute experiments and experimental campaigns. This would entail a number of personnel actions. First, steps should be taken to make an experimental assignment an attractive one. As an example, it would send a strong message if key performers are given preferential promotions/assignments. In addition, these assignments to the experimentation process should be of sufficient duration to allow key individuals to spend adequate periods of time during the experimental life cycle.



Selected Findings. Several presentations at the mini-symposium/workshop noted that participation in experiments has frequently been neither continuous nor universal. Thus, selected participants have been involved in the experiment sporadically, to the detriment of the total process. For example, it has not been unusual for assessors to become involved late in the process, adversely affecting their ability to shape and implement assessment activities.

The key finding in this category deals with the issue of "piggybacking." In this concept, a joint experiment attempts to take advantage of the resources that have been assembled by a service experiment, to satisfy joint objectives. It was noted that, while this concept is seductively attractive, it is **very** difficult to do **well.**

Conclusions. In order for an experiment to be conducted effectively and efficiently, it requires a high performance team to work together. This suggests that the key participants need to get involved throughout an experimental campaign.

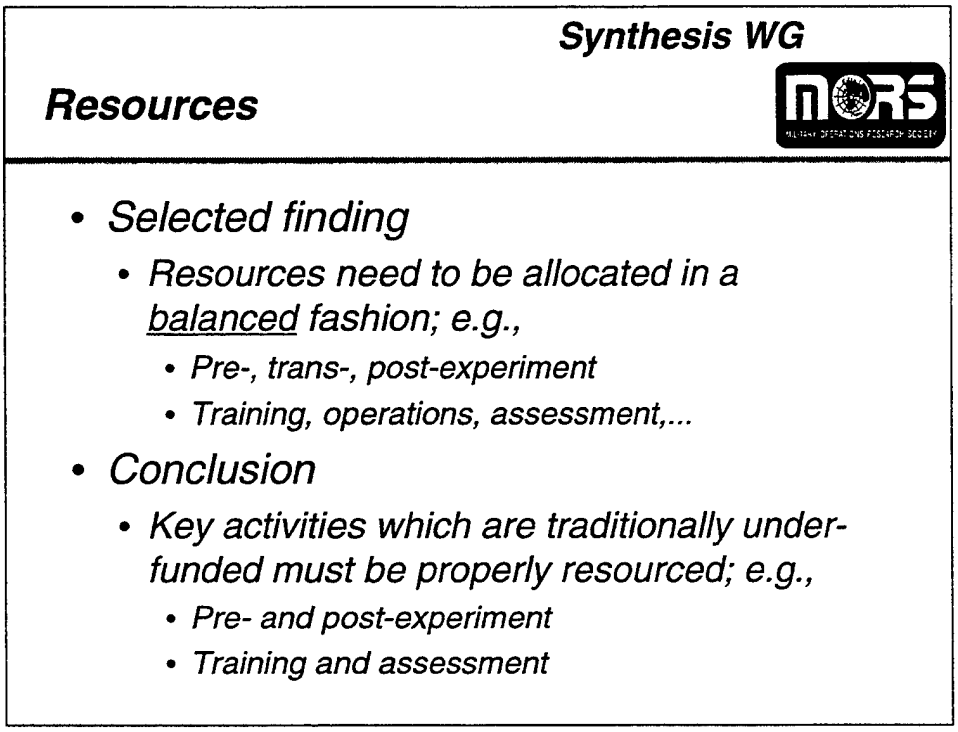


The above cartoon highlights the difference between the piggybacking concept and the reality. In the concept, the joint experiment takes advantage of the resources assembled by a Service experiment (without adversely affecting the Service's goals and objectives).

The reality tends to be quite different. For example, Information Superiority Experiment (ISX) 1.1 sought to piggyback on EFX 98. By providing $3.4M, ISX 1.1 more than doubled the live fly component of EFX 98, thereby enhancing the value of the latter activity. However, limitations imposed by EFX 98, adversely affected the success of ISX 1.1 (see reference 2).

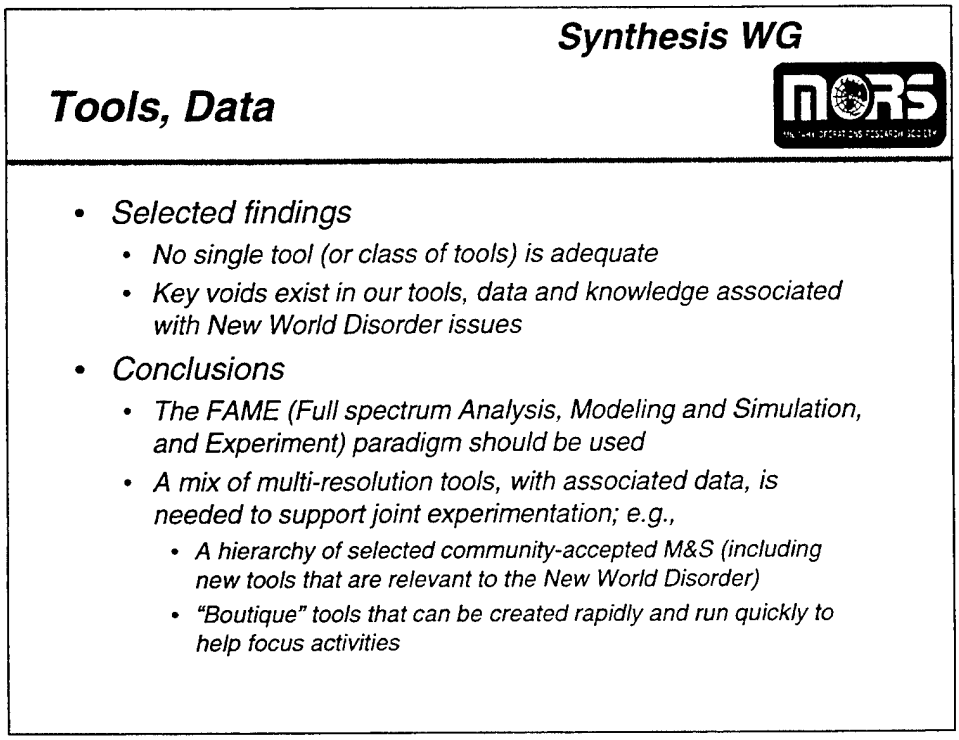
Reference 2 concluded that piggybacking can be successful only if both parties regard it as a "win-win" experience. To that end, they derived the following necessary conditions for piggybacking success:

- High level visibility and leverage.
- Formal agreement to collaborate.
- Agreement that piggybacking is equitable for **all** participants ("win-win").
- Sufficient influence on the scenario to tailor it.
- Early involvement in the planning process (e.g., deconfliction, resource allocation).
- Sufficient resources for training, data collection and analysis.
- A robust experimentation environment; including adequate number, variety of experimental events, instrumentation and free play (opportunities to fail).



Selected Findings. In order to perform an experiment successfully, it requires the balanced performance of a number of functions. Temporally, it can be viewed as balance across the phases of an experiment (pre-, trans- and post-experiment) and the individual functions that must be performed during the experimental life cycle (e.g., training, operations, assessments...)

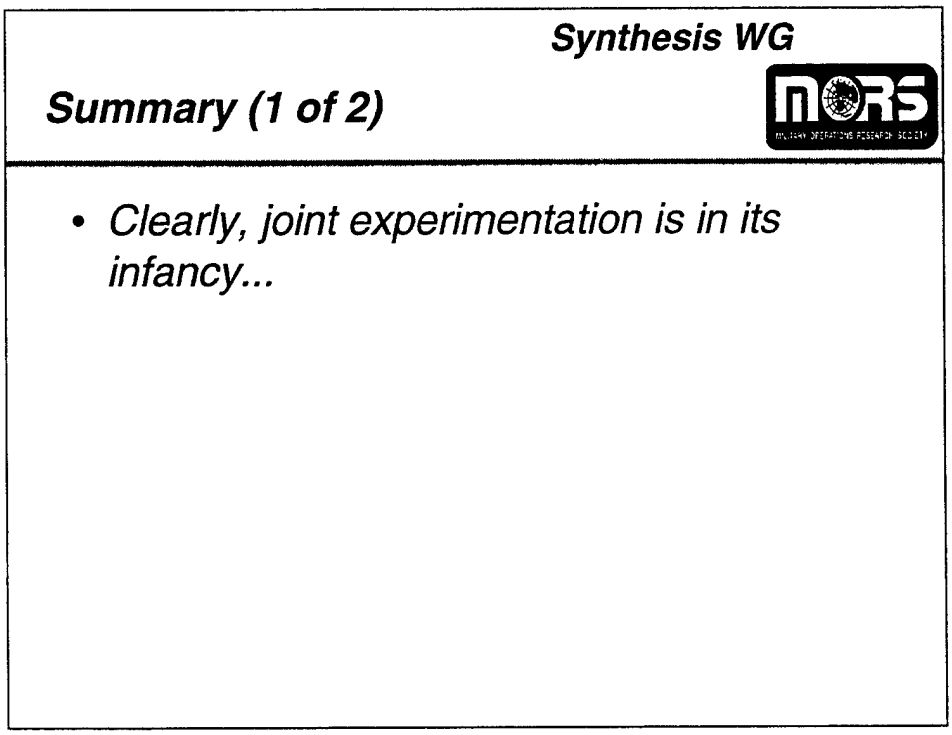
Conclusions. In recent experiments, we have witnessed the failure to allocate resources across key phases and functions in a balanced way. For example, it has been reported in reference 2 that the pre- and post-experiment phases of ISX 1.1 were underfunded and that in numerous other experiments, training and assessment were underfunded.



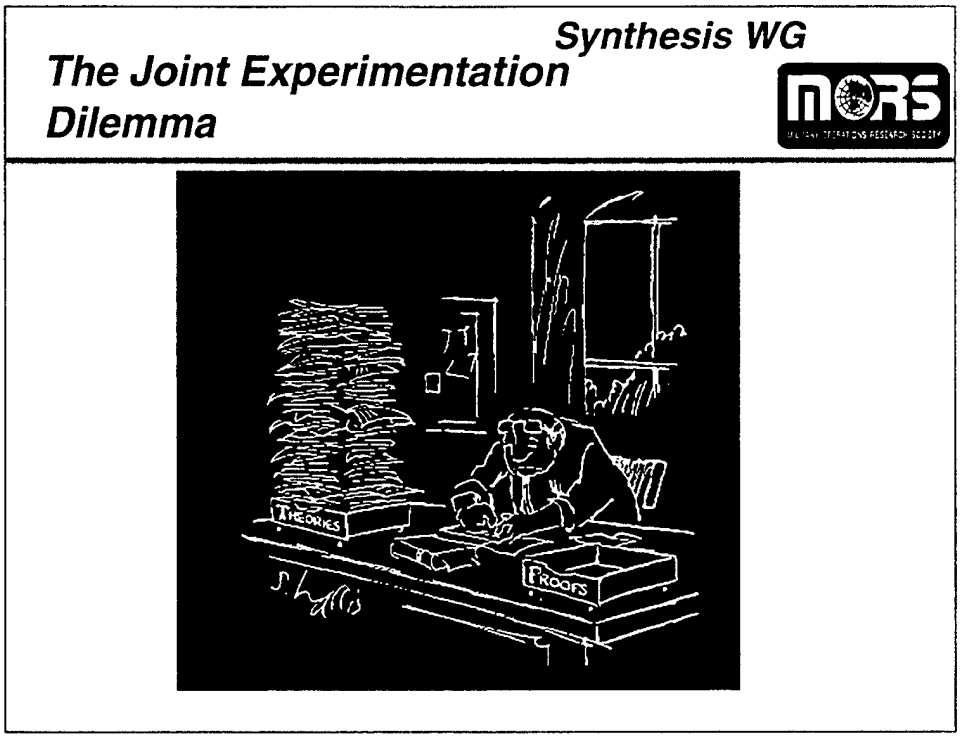
Selected Findings. There is a tendency to equate "experiment" with "live Modeling and Simulation (M&S)." However, the full experimental life cycle calls for multiple orchestrated tools, subsuming expert elicitation, analysis, system dynamics models, constructive M&S, virtual M&S, as well as live M&S. In addition, as we begin to consider the challenges of experimenting with new world disorder issues (e.g., critical infrastructure protection, peacemaking/peacekeeping), it becomes apparent that key voids exist in our tools, data and knowledge.

Conclusions. Consistent with the recommendations of the other working groups, it is agreed that a full spectrum analysis, Modeling and Simulation and Experiment (FAME) paradigm should be used.

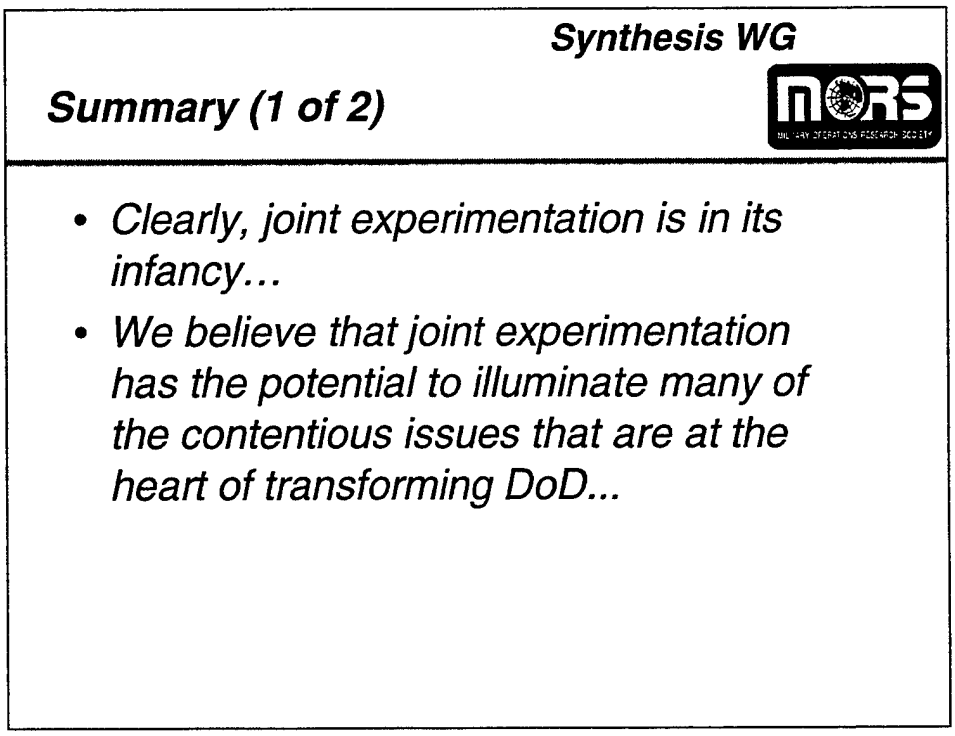
To implement this paradigm, a mix of multi-resolution tools, with associated data, are needed to support joint experimentation. This tool set should contain both a hierarchy of selected community-accepted M&S (including new tools that are relevant to the new world disorder and a set of "boutique" tools that can be created rapidly and run quickly to help focus activities.



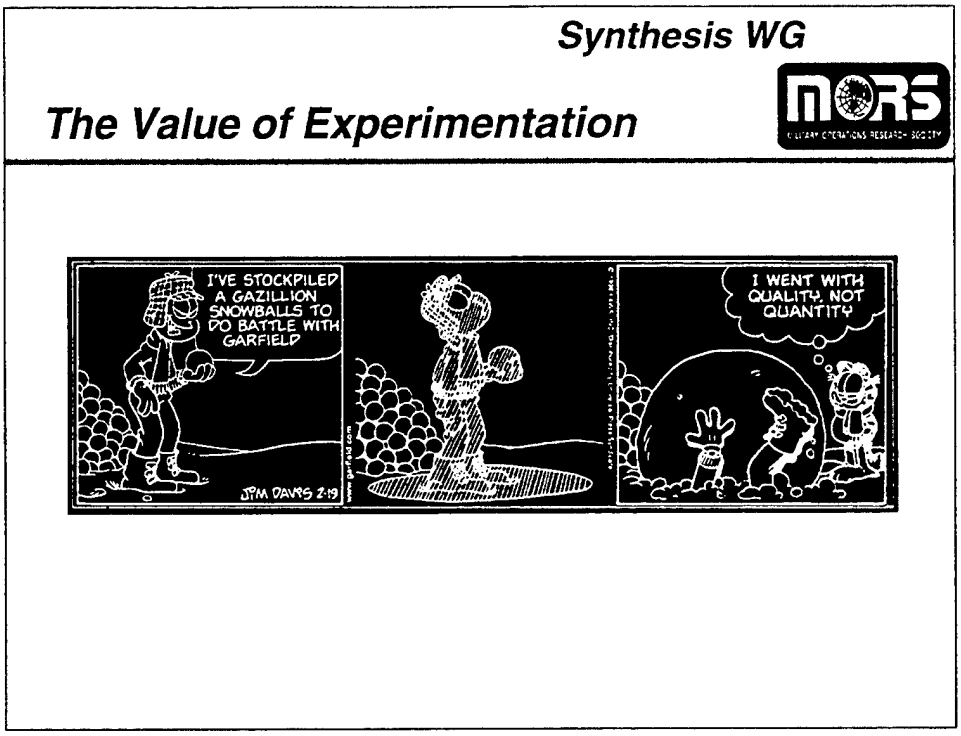
Based on the presentations that were given at the mini-symposium and the deliberations during the workshop, it is clear that joint experimentation is in its infancy.



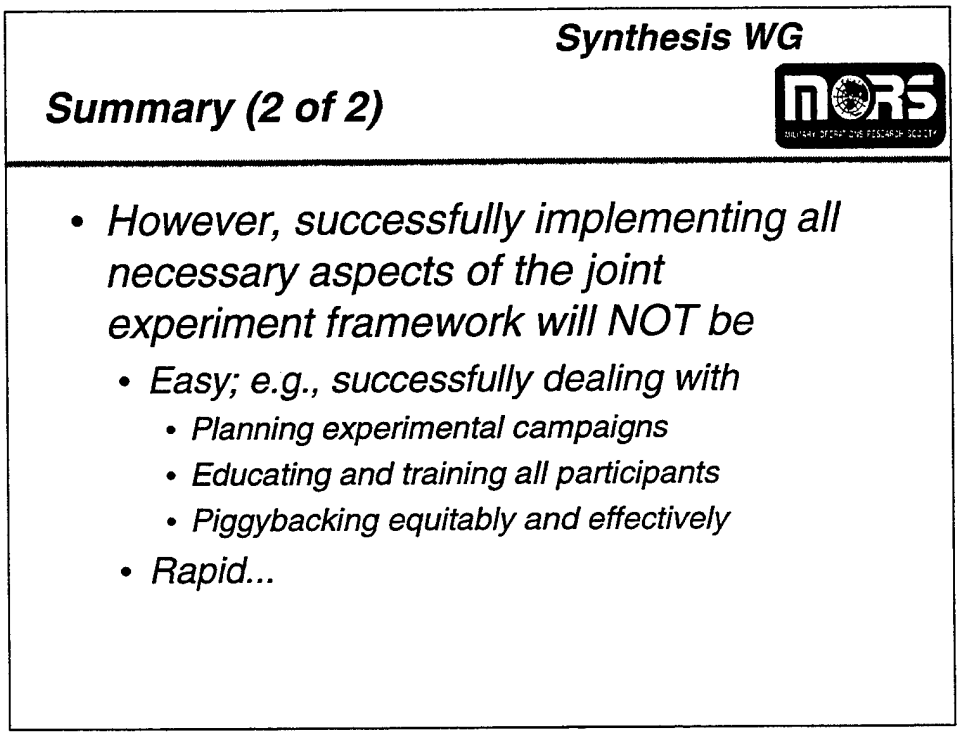
One manifestation of that immaturity is suggested by the above cartoon. At this point, we have many theories about new operational concepts that could conceivably revolutionize warfare, but no conclusive proof that these operational concepts will realize their potential.



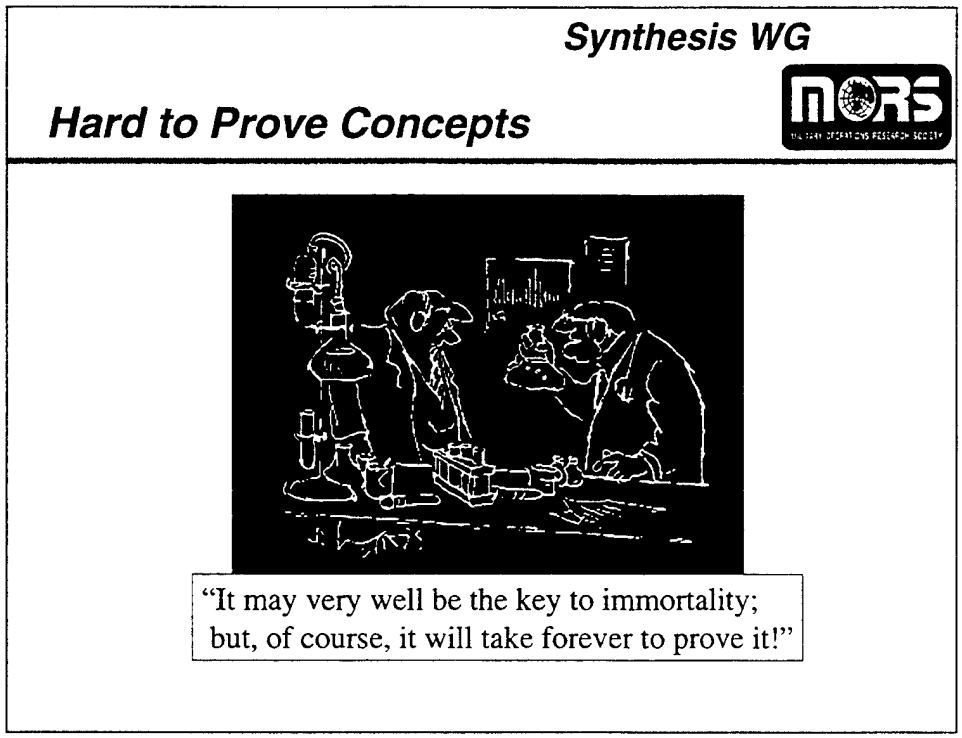
The Synthesis Working Group believes that joint experimentation has the potential to illuminate many of the contentious issues that are at the heart of transforming DoD.



For example, one of the age old issues in DoD is the proper balance between the quality and quantity of weapon systems. The above cartoon suggests that a well-designed experiment might shed some light on that issue.



However, the Synthesis Working Group concluded that successfully implementing all necessary aspects of the joint experiment framework will NOT be easy. Foremost among the obstacles are the challenges associated with successfully planning experimental campaigns, educating and training all the participants in an experiment and piggybacking joint experiments equitably and effectively on service experiments.



In addition, the Synthesis Working Group concluded that successfully implementing all necessary aspects of the joint experiment framework will NOT be rapid. As suggested in the above cartoon, the complexity and dimensionality of the issues will require a long term commitment before the decision maker will have sufficient information so that he can transform the DoD with confidence.

References:

1. "Management Actions and Tactics of Innovation," Under Secretary of Defense (Policy), 1995 Summer Study, Organized by the Director, Net Assessment, Newport, Rhode Island, 31 July - 9 August 1995.

2. "Lessons Learned from Information Superiority Experiment (ISX) 1.1," D. Alberts, F. R. Richards, & S. Starr, Proceedings of 1999 Command and Control Research & Technology Symposium, Newport, RI, 29-30 June, 1 July 1999.

Military Operations Research Society
Joint Experimentation Mini-Symposium and Workshop

ACRONYMS

ACOM	Atlantic Command
ACTD	Advanced Concept Technology Demonstration
AFEO	Air Force Experiment Office
AFIT	Airforce Institute of Technology
AWE	Advanced Warfighting Experiment
BOGSATs	Bunch of Guys/Gals Sitting Around A Table
C^2	Command and Control
C^4ISR	Command, Control, Communication, Computers, Intelligence, Surveillance and Reconnaissance
CINC	Commander-in-Chief
CJCS	Chairman of the Joint Chiefs of Staff
COBP	Code of Best Practices
CONOPS	Concept of Operations. A verbal or graphic statement, in broad outline, of a commander's assumptions or intent in regard to an operation or series of operations. The concept of operations frequently is embodied in campaign plans and operation plans; in the later case, particularly when the plans cover a series of connected operations to be carried out simultaneously or in succession. The concept is designed to give an overall picture of the operation. It is included primarily for additional clarity of purpose.
DCINC	Deputy Commander-in-Chief (BMDO)
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DoE	Design of Experiments
DOTMLP	Doctrine, Organization, Training, Materiel, Leadership and Personnel
DPG	Defense Planning Guidance
DUSD	Deputy Under Secretary of Defense (BMDO)
ED	Experiment Directive/Experiment Director
EFX	Expeditionary Forces Experiment
EXFOR	Exercise Force
FAME	A Full spectrum Analysis employing Modeling techniques, tools and Experiments
FEDEP	Federal Execution and Development Process
FFRDC	Federally Funded Research and Development Plan
FINPLAN	Financial Plan
HLA	High Level Architecture
IAW	In Accordance With
IIM	Initial Insights Memorandum
ISX	Information Superiority Experiment
JCFAWE	Joint Contingency Force Advanced Warfighting Experiment
JE	Joint Experimentation
JROC	Joint Requirements Oversight Council
JULL	Joint Universal Lessons Learned
LAN	Local Area Network
LCM	Life Cycle Management
M&S	Modeling and Simulation

M-E-M	Model-Exercise-Model
MLS	Multiple Levels of Security
MOE	Measure of Effectiveness
MOP	Measure of Performance
MORS	Military Operations Research Society
MOUs	Memorandum of Understanding
MOUT	Military Operations in Urban Terrain
M-T-M	Model-Test-Model
NDP	National Defense Panel
NPS	Naval Postgraduate School
OASD	Office of Assistant Secretary of Defense
OOTW	Operations Other Than War
OPFOR	Opposing Force
ORSA	Operations Research/Systems Analysis
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
OTA	Operational Test Agencies
R&D	Research and Development
ROI	Return on Investment
SME	Subject Matter Experts
T&E	Test and Evaluation
TOR	Terms of Reference
UFR	UnFunded Resources
USACOM	US Atlantic Command
VIP	Very Important Person
VVA	Verification, Validation and Accreditation
RoE	Rules of Engagement
WMD	Weapons of Mass Destruction

Military Operations Research Society
Joint Experimentation Mini-Symposium and Workshop
Terms of Reference
2 February 1999

Background

The Revolution in Military Affairs is transforming not only our technological capabilities, but also our organizational structure, doctrine, leadership and training requirements. The pace of change is too fast for us to wait until the technologies are in place before learning how to exploit them. Experiments are a way to bridge this gap. Well designed and conducted experiments can point the way to the required organizational, doctrinal and cultural changes that best take advantage of the opportunities offered by advancing technologies.

Experimentation will play a pivotal role in our journey to Joint Vision 2010 and beyond. Effective 1 October 1998, the Commander-in-Chief, U.S. Atlantic Command (CINCUSACOM) is the Defense Department's Executive Agent for Joint Experimentation. CINCUSACOM has the authority and responsibility for developing and implementing an aggressive program of experimentation to foster innovation and rapid fielding of new concepts and capability for joint operations. The Joint Experimentation Implementation Plan (IPLAN) establishes the experimentation process and explains how the USACOM Joint Experimentation program relates to, supports, and leverages the activities of the other components of the Joint Vision 2010 implementation process. USACOM and the services will plan, conduct and assess concept-based experiments to determine how organization, doctrine, etc. will co-evolve to leverage the capacity of emerging technologies. Experimentation is an iterative process for assessing concept-based hypotheses to identify and recommend the best value-added solution for change to doctrine, organization, training, material, leadership and personnel (DOTMLP) required to achieve significant advances in future joint operational capabilities.

The analytic community must posture itself to address the analysis of the results of these experiments. This special meeting, comprising analysts and operational experts, will concentrate on assessing and improving the community's ability to plan, conduct and analyze the results of concept-based experiments laid out in the Joint Experimentation Campaign Plan.

Goals and Objectives

Goal

The goal of this mini-symposium and workshop is to contribute to planning, conduct, and exploitation of Joint Experiments by leveraging the experience and expertise of the analytical community.

Objectives

The mini-symposium will inform participants about the nature of ongoing military experimental activities.

The workshop will:
Identify ways that concept-based experimentation can contribute to the achievement of JV2010 and other future operational concepts.

1. Identify appropriate metrics, methodologies and tools for concept-based experiments.

2. Identify the critical issues in planning, conducting, and analyzing the results of experiments including hypotheses generation, experimental control issues (e.g. man-in-the-loop, free play), measurement and methods of data collection and analysis, the need for replicability, and training and learning curves.

3. Identify ways to federate and utilize existing models to help address specific hypotheses. Identify opportunities for developing strategic joint experimentation plans to synchronize DoD experimental activities.

4. Identify the analytical issues associated with concept development and prioritization.

5. Develop pragmatic guidelines for conducting valid experiments whose results can be shared, while supporting the needs of the operational community.

6. Evaluate current tools and models to assess their applicability to concept-based experiments and identify requirements for future analysis tools (e.g. models, simulations, and other analysis tools or techniques).

7. Establish the practical limits of modeling, simulation, and analysis as applied to large scale experiments.

Approach

This will be a three-phase effort consisting of pre-workshop working group, a mini-symposium, and a workshop. The pre-workshop working group will be focused upon considering the nature and role of experimentation in the process of designing and developing future mission capability packages. The results of this working group effort will be presented as a point of departure for the workshop's deliberations. The mini-symposium directly preceding the workshop will consist of a number of presentations that address ongoing and planned experimental activities being undertaken throughout DoD. The workshop will be organized into a set of the following working

groups that will examine issues related to Joint Experimentation from a number of different perspectives.

1. Planning Experiments: Individually and as part of a campaign

2. Design of Experiments

3. Preparation & Conduct of Experiments
   - Site and Experimental Preparation
   - Data Collection and Instrumentation
   - Field Test Issues and Restrictions
   - Experimental Infrastructure Requirements

4. Modeling/Simulation & War Gaming in Support of Experimentation
   - Balance Constructive vs. Live
   - M & S in Experimental Design and Concept Development
   - M & S to Exploit Experimental Results

5. Assessment & Utilization of Experimental Results
   - Analysis and Assessments of Concepts; Integration Across Experiments
   - "Validation" of Experiments
     Synthesis

Tasking

The workshop attendees will be divided into working groups (15-18 members each) to examine various experimentation issues from a given perspective. Each working group will:

1. Identify the issues germane to their area;

2. Consider the issues in light of the goals and objectives of the workshop;

3. Assess our ability to plan, conduct, and analyze within the context of the working group;

4. Identify promising approaches, tools, etc.;

5. Suggest actions that need to be taken to improve our ability to undertake the kind of experimentation program needed.

List of Working Group Chairs and Co-Chairs

MORS Joint Experimentation Mini-Symposium & Workshop Working Groups & Chairs

Title	Chair	Co-Chair	ACOM Co-Chair	Synthesis Group Representative
Planning Experiments	Marion Williams	Col. Steve Myer	Joe Jennings	Dave Signori
Design of Experiments	Bob Sheldon	Daniel Serfaty	Capt Johnson	Dick Hayes
Preparation & Conduct of Experiments	Don Eddington	Richard Kass	COL Geraci	Ken Jordan
Modeling/Simulation & War Gaming in Support of Experimentation	David Noble	Bill Stevens	Maj Ike Eichenberger	Russ Richards
Assessment & Utilization of Experimental Results	Jackie Henningsen	Priscilla Glasow	Linda Weber	Leland Joe
Synthesis	Stu Starr	Dave Alberts	Col Gallinetti	N/A

Administration
Name: Joint Experimentation
Dates: 8 - 11 March 1999
Location: Armed Forces Staff College
Fee: Mini-Symposium Only: Federal Government Employees: $75; All others: $150
Mini-Symposium and Workshop: Federal Government: $180; All others: $360
Attendance: Mini-Symposium — Can accommodate up to 500 people;
Workshop -- Limited to 150 by invitation only
Classification: UNCLASSIFIED

Military Operations Research Society
Mini-Symposium/Workshop
Joint Experimentation
Participants

Ms Natalie S Addison
MORS
101 S. Whiting Street
Alexandria VA 22304
OFF: 703-751-7290 FAX: 703-751-8171
Email:morsvpa@aol.com

Mr. J. L Adkinson
Marine Corps Warfighting Lab (EDO,TSA)
3255 Myers Ave
Quantico VA 22134
OFF: 703-784-5167 DSN: 278 FAX: 703-784-4597
Email:adkinsonl@mcwl.quantico.mil

DR David S Alberts
OASD (C3I)
Room 3E172
6000 Defense Pentagon
Washington DC 20301-6000
OFF: 703-695-7183 FAX: ((703) 614-8060
Email:David.Alberts@osd.pentagon.mil

MR William R Aldridge
SETA Corporation
6862 Elm Street
McLean VA 22101-3833
OFF: 703-695-1763 DSN: 225-1763 FAX: 703-693-4601
Email:aldridwr@js.pentagon.mil

Dr Robert Steven Alexander
SAIC
Suite 1010
110 N Glebe Road
Arlington VA 22201
OFF: (703)-907-2547 FAX: 703-276-3055
Email:ralexander@sito.saic.com

COL Gary Anderson
Marine Corps Warfighting Lab
3255 Meyers Ave
Quantico VA 22134
OFF: 703-784-5096 DSN: 278 FAX: 703-784-4597
Email:andersong@mcwl.quantico.usmc.mil

MR Gary W Arnett
Synergy, Inc.
1763 Columbia Road, NW
Washington, DC 20309
OFF: (202)-232-6261 FAX: (202)-232-8359
Email:garnett@synergyinc.com

Mr. Edward M Ashley
SAIC
22 Enterprise Pkwy
Hampton VA 23666
OFF: 757-827-2620 FAX: 757-825-9104
Email:edward.m.ashley@cpmx.saic.com

Mr. Grant Ayers
USACOM/J92
PO Box 51302
Ft Monroe, VA 23651-1302
OFF: 757-726-6279 DSN: 680-6279 FAX: 757-726-6229

MR Dennis R. Baer
Logicon
2100 S Washington Blvd
Arlington VA 22204-5703
OFF: (703)-312-2149 FAX: (703)-312-2780
Email: dbaer@logicon.com

Mr. John Baird
Raytheon Systems Company
STE 230
6225 Brandon Ave
Springfield VA 22150
OFF: 703-923-2130 FAX: 703-923-2205
Email:jbaird@rayva.org

CAPT Gary Barrett

Dr Stephen A Basile
The Johns Hopkins University
Applied Physics Lab
11100 Johns Hopkins Road
Laurel MD 20723-6099
OFF: 240-228-4995 FAX: 240-228-8240
Email:stephen.basile@jhuapl.edu

Dr. Umit Basoglu
Intergraph Corporation
2051Mercator Drive
Reston VA 20191
OFF: 703-264-5680 FAX: 703
Email:ubasoglu@ingr.com

MR Michael F. Bauman
US Army TRADOC Analysis Center
ATTN: ATRC
255 Sedgwick Ave
Fort Leavenworth KS 66027-2345
OFF: (913)-684-5132 DSN: 552-5132 FAX: (913)-684-6894
Email:baumanm@trac.army.mil

MAJ James B Bearden
AC2ISRC
130 Andrews St., Suite 216
Langley AFB, VA 23665-1993

COL Raymond Beaulieu
SACLANT, NATO
STE 100
7857 Blandy Road
Norfolk VA 23551
OFF: 757-445-3259 DSN: 565 FAX: 757-445-3271
Email:beaulieu@saclant.nato.int

Mr Joseph C Bonnet
SETA Corporation
6862 Elm Street
McLean VA 22101-3833
OFF: 703-695-4657 DSN: 225-4657 FAX: 703-695-8031
Email:bonnetjc@js.pentagon.mil

MS Mary T Bonnet
AFSAA/SAJ
1570 Air Force Pentagon
Washington DC 20330-1570
OFF: 703-588-6910 DSN: 425-6910 FAX: 703-588-8779
Email:Mary.Bonnet@pentagon.af.mil

MR Michael Borowski
MITRE Corporation
1820 Dolley Madison Blvd
MS W625
McLean VA 22102-3481
OFF: 703-883-5216 FAX: 703-883-1370
Email:borowski@mitre.org

Dr. J W Bovenkamp
Department of National Defence
Defence Research & Development Branch
190 O'Connor St,
Ottawa, Ontario CANADA KIA-IG8
OFF: 613-996-0292 FAX: 613-996-0038
Email:John.Bovenkamp@crad.dnd.ca

Mr. Peter Bretherton (UK)
NATO SACLANT HQ
STE 100
7857 Blandy Road
Norfolk VA 23551-2490
OFF: 757-445-3598 FAX: 757-445-3242
Email:bretherton@saclant.nato.int

Mr. Carl A Cafiero
SYNERGY, Inc
3302 Running Cedar Way
Williamsburg VA 23188
OFF: 757-258-4540 FAX: 757-565-5212
Email:ccafiero@synergyinc.com

MR Howard J Carpenter
The MITRE Corporation
MS W643
1820 Dolley Madison Blvd
McLean VA 22102
OFF: (703)-883-5469 FAX: (703)-883-1279
Email:howard@mitre.org

MR Frederic T Case
JHU/APL
OFF: 240-228-8740
Email:fcase@jhuapl.edu

Mr. Marvin E. Casterline
US GAO
441 G Street, NW
Washington, DC 20548
OFF: 202-512-9076 FAX: 202-512-7981

MR Gary Q Coe
Institute for Defense Analyses
1801 N Beauregard Street
Alexandria VA 22311

COL Michael W Cole
USAF C2TIC
138 Hartson St
Hurlburt Field FL 32544
OFF: 851-884-2800 DSN: 519 FAX: 850-884-6181

Mr. Thomas Connors
SYNERGY, Inc
1763 Columbia Rd, NW
Washington DC 20009
OFF: 757-825-6227 FAX: 757-852-8246
Email:tconnors@synergyinc.com

Dr Thomas M Cook
Army Research Laboratory
Human Research & Engineering Directorate
Bldg 459
Aberdeen Proving Ground MD 21005-5425
OFF: 410-278-2573 FAX: 410-275-8830
Email:tmcook@arl.mil

Lt Gen Stephen B. Croker, USAF-Ret

Mr. Joseph M Cummings
OSD JSEAD JTF
5490 Pease Drive
Bldg 1114
Nellis AFB NV 89191-7012
OFF: 702-652-6867 DSN: 682-6867 FAX:
Email:cumminsj@jsead.com

Mr. Kenneth Dahl
AC2ISRC/AFEO
STE 216
130 Andrews St
Langley AFB VA 23665-1993
OFF: 757-825-8234 DSN: 574-9945 FAX: 757-825
Email:Kenneth.dahl@langley.af.mil

LTC Peter A Davidson
US Army OPTEC
4501 Ford Ave
Washington DC 20301-0400
OFF: 703-681-9221 DSN: 761-9221 FAX: 703-681-9787
Email:davidsonpeter@hq.optec.army.mil

DR Paul K Davis
RAND
PO BOX 2138
1700 Main St
Santa Monica CA 90407-2138
OFF: (310)-451-6912 FAX: (310)-451-7066
Email:paul.davis@rand.org

MR George DeGovanni
CACI
1600 Wilson Blvd #1300
Arlington VA 22209
OFF: (703)-558-0281 FAX: (703)-875-2904
Email:gdegovanni@hq.caci.com

Raymond Duffy
Logicon Syscon
STE 200
484 Viking Drive
Virginia Beach VA 23456
OFF: 757-486-4411 FAX: 757-486-2651
Email:rduffy@logicon.com

Mr. Stephen M Dwyer
SAIC
STE150
116 lakeview Pkwy
Suffolk VA 23435-2697
OFF: 757-686-7542 DSN: 564-9100 FAX: 757-686-7087
Email:dwyer@jbc.js.mil

MAJ Kenneth P Dzierzanowski
TRADOC Analysis Center
Attn: WBB
White Sands Missile Range NM 88002-5502
OFF: 505-678-3729 DSN: 258-3729 FAX: (505)-678-5104
Email:dzierzak@trac.wsmr.army.mil

Mr. Joseph J Eash III
Deputy Under Secretary of Defense
Advanced Systems & Concepts
3700 Defense Pentagon
Washington DC 20301-3700
OFF: 703-697-6446 FAX: 703-614-6829

CAPT Robert W Eberth USNR
OPNAV N85/Marine Corps Warfighting Lab
2006 Hawkins Ave
Quantico VA 22134
OFF: 703-784-3785 DSN: 278-3785 FAX: 703-784-4421
Email:eberthr@mcwl.quantico.usmc.mil

Maj William Eichenberger
USACOM/J95
STE 200
1562 Mitscher Ave
Norfolk VA 23511
OFF: 757-726-6228 DSN: 680-6223 FAX:
Email:eichenb@acom.mil

John M Elder
The MITRE Corporation
P.O. Box 8068
Camp Lejeune NC 28547-8068
OFF: 910-451-5869 DSN: 751-5869 FAX: 910-451-9422
Email:jmelder@mitre.org

Mr. Elliot E Entin
ALPHATEC, Inc
50 Mall Road
Burlington MA 01803
OFF: 781-273-3388 FAX: 781-273-9345
Email:elliot@alphatec.com

Mr. Arthur J Faint
The MITRE Corporation
MS K223
202 Burlington Road
Bedford MA 01730
OFF: 781-271-7823 FAX: 781-271-2128
Email:ajfaint@mitre.org

Mr. Bernard B Ferguson
Joint Test and Evaluation Program
Support/SAIC
2001 N. Beauregard St
Alexandria VA 22311
OFF: 703-578-8222 FAX: 703-57/-6172
Email:ferguscf@acq.osd.mil

Mr Robert J Fleming
Camber Corporation
Suite 800
2 Eaton Street
Hampton VA 23669
OFF: 757-727-7952 FAX: 757-727-7954
Email:bfleming@camber.com

MAJ Steven L. Forsythe
AFSAA
1570 Air Force Pentagon
Washington DC 20330-1570
OFF: 703-588-8292 DSN: 425-8292 FAX: 703-588-8779
Email:steven.forsythe@pentagon.af.mil

MS Christine A Fossett FS
US GAO
NSIAD/MOC, Room 4930
441 G Street, NW
Washington DC 20548
OFF: (202)-512-2956 FAX: (202)-512-7982
Email:fossettc.nsiad@gao.gov

MR W. Dean Free
Chief of Naval Operations (N816)
2000 Navy Pentagon
Washington DC 20350-2000
OFF: (703) 697-0679 DSN: 227-0679 FAX: (703)-697-0738
Email:free.dean@hq.navy.mil

Mr. Robert L French
AC2TSRC/AFEO
STE 216
130 Andrews St
Langley AFB VA 23665-1993
OFF: 757-825-8234 DSN: 574 FAX: 757-825-9945
Email:bob.french@langley.af.mil

Ms. Colleen Gagnon
Metron, Inc
Simulation Sciences Division
512 Via de la Valle, STE 301
Solana Beach CA 92075
Email:gagnon@ca.metsci.com

COL Jon A Gallinetti
Joint Experimentation (J9 USACOM)
STE 200
1562 Mitscher Ave
Norfolk VA 23511-2488
OFF: 757-836-6473 DSN: 836 FAX: 757-836-6478
Email:gallinet@acom.mil

LTC Hoa Generazio
US Army TRADOC Analysis Center
200 Army Pentagon
Washington DC 20301-0200
OFF: 703-693-0506 DSN: 223 FAX: 703-697-8713
Email:generho@hqda.army.mil

COL Richard Geraci
USACOM J9
1562 Mitscher Ave STE 200
Norfolk VA 23551-2488
OFF: 757-836-0693 FAX: 757-836-0932
Email:geraci@acom.mil

MRS Priscilla A Glasow
The MITRE Corporation
MS W626
1820 Dolley Madison Blvd
McLean VA 22102
OFF: (703)-883-6931 FAX: (703)-883-1370
Email:pglasow@mitre.org

Mr. Patrick A Gorman
Booz-Allen & Hamilton Inc
8283 Greensboro Drive
McLean VA 22102-3838
OFF: 703-902-3213 FAX: 703-402-3392
Email:Gorman_Patrick@bah.com

Mr Robert J Graebener
IDA
SIM Center
1801 N Beauregard
Alexandria VA 22311
OFF: 703-845-6744 FAX: 703-845-6809
Email:rgraeben@ida.org

MR John W Gray
AB Technologies Inc
c/o MSOSA, Suite 400
1901 N Beauregard Street
Alexandria VA 22311-1705
OFF: (703)-998-1623 FAX: (703)-998-1625
Email:jgray@msosa.dmso.mil

Mr. Frank T Gross
Cubic Applications Inc (J-97)
19 Windy Point Drive
Hampton VA 23662
OFF: 757-726-6164 FAX: 757-726-6181
Email:grossj@jwfc.js.mil

Dr Jon G Grossman
RAND
1700 Main Street
Santa Monica CA 90407
OFF: 310-393-0411 FAX: 310-451-7038
Email:jon_grossman@rand.org

Mr. Roderick Hallum
Intergraph Corporation
STE 1130
500 East Main St
Norfolk VA 23510
OFF: 757-640-7735 FAX: 757-640-1572
Email:rwhallum@ingr.com

Mr. Fred S Harrison
US GAO
STE 300
5029 Corporate Woods Dr
Virginia Beach VA 23462
OFF: 757-663-8130 FAX: 757-552-8197
Email:harrisonf.noro@gao.gov

DR Dean S Hartley III
Data Systems R&D Program
1099 Commerce Park
Oak Ridge TN 37830
OFF: (423) 574-7670 FAX: (423) 574-0792
Email:dhx@ornl.gov

Mr. Bryan H Hartwig
BMDO/Joint National Test Facility
720 Irwin Ave
Falcon AFB CO 80912-7200
OFF: 719-567-8386 FAX: 719-570-6887
Email:bhartwig@jntf.osd.mil

Maj Gen John W. Hawley
AC2ISRC/CC
130 Andrews Street
Suite 216
Langley AFB, VA 23669-1993
OFF: 757-764-3271

DR Richard E Hayes
Evidence Based Research, Inc
STE 250
1595 Spring Hill Road
Vienna VA 22182-2228
OFF: (703)-893-6800 FAX: (703)-821-7742
Email:rehayes@ebrinc.com

DR Jacqueline R. Henningsen FS
HQ USAF AXOC
Rm 4E1041
1480 Air Force Pentagon
Washington DC 20330-1480
OFF: 703-692-9661/2 DSN: 222-9661 FAX: 703-695-5758
Email:henningsenj@pentagon.af.mil

MR Mark L. Herman
Booz Allen & Hamilton
8283 Greensboro Drive
McLean VA 22102
OFF: (703)-902-5986 FAX: (703)-902-3392
Email:herman_mark@bah.com

Maj Gen Kenneth W. Hess
HQ USAF/XOC
Director of Command and Control
DCS Air and Space Operations
1480 Air Force Pentagon Rm 4C1059
Washington, DC 20330
OFF: 703-695-1833 DSN: 225-1833 FAX: 703-693-1161

MR James W Heusmann
Defense Modeling and Simulation Office
Suite 500
1901 N. Beauregard Street
Alexandria VA 22311
OFF: 703-824-3413 FAX: 703-998-0667
Email:heusmann@msis.dmso.mil

Mr. David G Hoagland
AFRL/HECI
2210 8th Street
Wright-Patterson AFB OH 45433-7511
OFF: 937-656-7013 DSN: 986-7013 FAX: 937-656-4547
Email:dhoagland@al.wpafb.af.mil

MR James C Hoffman
SETA Corporaton
c/o Room 1A720
JCS/J8/JWAD Pentagon
Washington DC 20318-8000
OFF: (703)-697-0499 DSN: 227-0499 FAX: (703)-614-4141
Email:hoffmajc@js.pentagon.mil

Mr. Gerard Horton
EDO Technology Services & Analysis
1801 E Sara Drive
Chesapeake VA 23320
OFF: 757-424-1004 FAX: 757-424-8000
Email:jhorton@edo-tsa.com

Mr. Charles R Hughes
US Atlantic Command, J9
1562 Mitscher Ave, STE 2000
Norfolk VA 23551
OFF: 757-836-0704 DSN: 836-0704 FAX: 757-836-0932
Email:hughesc@trac.wsmr.army.mil

Mr. Stephen B Husak
Litton-TASC
1104 Bruton Lane
Virginia Beach VA 23451
OFF: 757-4226616 FAX: 757-422-6616
Email:shusak@exis.net

Mr. David L Ingle
SAIC/Joint C4ISR Battle Cetner (JBC)
116 Lakeview Pkwy
Suffolk VA 23435-2697
OFF: 757-686-7085 DSN: 564-9100 FAX: 757-686-6174
Email:ingle@jbc.js.mil

LTC Peter R Itao
TRADOC Analysis Center
Attn: ATRC
255 Sedgwick Ave
Fort Leavenworth KS 66027-2345
OFF: 913-684-7582 DSN: 552 FAX: 913-684-6894
Email:itaop@trac.army

COL Jack A Jackson
IDA/JAWP
1801 N. Beauregard Street
Alexandria VA 22311
OFF: 703-578-2882 FAX: 703-845-6810
Email:jajackso@ida.org

Mr Joseph B Jackson
The MITRE Corporation
Suite 400
7941 Blandy Road
Norfolk VA 23551-2498
OFF: 757-836-7322 DSN: 836-7322 FAX: 757-836-6470
Email:jbjackso@mitre.org

MR Joseph F Jennings
MITRE/USACOM J9
STE 400
7941 Blandy Road
Norfolk VA 23551-2498
OFF: 757-836-2210 FAX: 757-836-6470
Email:jjenning@mitre.org

DR Leland T. Joe
RANDArroyo Center
PO Box 2138
1700 Main Street
Santa Monica CA 90407-2138
OFF: (310)-393-0411 FAX: (310)-451-6952
Email:leland_joe@rand.org

CAPT Aaron B Johnson
US Atlantic Command (J93)
1562 Mitscher Ave
Norfolk VA 23551-2488
OFF: 757-836-0695 DSN: 836 FAX: 757-836-0932
Email:johnson@acom.mil

DR Kenneth L. Jordan
SAIC
1710 Goodridge Dr MS1-4-8
McLean VA 22102-3799
OFF: (703)-734-5999 FAX: (703)-356-0959
Email:jordank@saic.com

DR Richard A Kass
US Army TEXCOM
Attn: CSTE-TAC
HQ TEXCOM 91012 Station Road
Fort Hood TX 76544-5065
OFF: 254-286-6470 DSN: 566-6470 FAX: 254-286-6474
Email:kassrichard@texcom-mail.army.mil

LTG Keane
DCINC USACOM
1502 Mitscher Ave
Suite 200
Norfolk, VA 23551-2488

Mr. Hugh A Kelley
The MITRE Corporation
STE 155
3504 Lake Lynda Drive
Orlando FL 32817-1472
OFF: 407-208-1320 FAX: 407-208-1380
Email:hkelley@mitre.org

Mr. Floyd D Kennedy Jr
Submarine Force Atlantic (N02E6)
7958 Blandy Road
Norfolk, VA 23551-2492
OFF: 757-836-1161 DSN: 836 FAX: 757-836-1799
Email:n02eg@hq.sublant.navy.mil

DR Robert M Kerchner
RAND
1333 H Street NW
Washington DC 20005-4707
OFF: (202)-296-5000 FAX: (202)-296-7960
Email:kerchner@rand.org

LtCol Rocky K Kimpel
AC2ISRC/AFEO
STE 216
Andrews St
130 Andrews St
Langley AFB VA 23665-1993
OFF: 757-825-8234 DSN: 574-9945 FAX: 757-825-9945
Email:rocky.kimpel@langley.af.mil

COL Thomas R King
MCCDC
Studies and Analysis Division (C45)
3300 Russell Street
Quantico VA 22134-5130
OFF: 703-784-6293 FAX: 703-784-3547
Email:kingtr@quantico.usmc.mil

Mr. Joseph Keith Kirkland
Evidence Based Research, Inc
STE 250
1595 Spring Hill Road
Vienna VA 22182
OFF: 703-287-0314 FAX: 703-821-7742
Email:kirkland@ebrinc.com

LtCol Jack M Kloeber Jr
AFIT/ENS
Bldg 640
2950 P Street
Wright-Patterson AFB OH 45433
OFF: (937)-255-6565 DSN: 785-6565 FAX: (937)-656-4943
Email:jkloeber@afit.af.mil

DR R. Royce Kneece
OSD PA&E
1800 Defense Pentagon
Washington DC 20301-1800
OFF: (703)-695-7835 FAX: (703)-695-7988
Email:Royce.Kneece@osd.pentagon.mil

DR Jerry A Kotchka
Boeing
Mail Code 0641251
PO Box 516
St. Louis MO 63166-0516
OFF: (314)-777-9990 FAX: (314)-232-7917
Email:jerry.a.kotchka@boeing.com

MR Donald W Kroening
US Army TRAC-SAC
ATTN: ATRC-SAS
255 Sedgwick Avenue
Fort Leavenworth KS 66027-2345
OFF: (913)-684-3330 DSN: 552-3330 FAX: 913-684-9109
Email:kroenind@trac.army.mil

MR William J Krondak
TRADOC Analysis Center
Attn: ATRC-SW
255 Sedgwick Ave
Fort Leavenworth KS 66027-2345
OFF: 913-684-9209 DSN: 552-9209 FAX: 913-684-9191
Email:krondakw@trac.army.mil

COL Ronald J Kurjanowicz
HQ USAF/XORB
STE 1200
1911 N Fort Myer Drive
Arlington VA 22209
OFF: 703-696-0133 DSN: 426 FAX: 703-696-0702
Email:bltforce1@pentagon.af.mil

LTC Michael Kwan
TRADOC Analysis Center
White Sands Missile Range NM 88002
OFF: 505-678-4300 DSN: 258 FAX: 505-678-1450
Email:kwanm@trac.wsmr.army.mil

COL Kent Kysar
USACOM J92
Fenwick Road, Bldg 96
Ft Monroe VA 23651
OFF: 757-726-6424 FAX: 757-726-6408
Email:kysark@jwfc.js.mil

MR Richard R LaFerriere
TRADOC Analysis Center
Attn: ATRC-WGA
White Sands Missile Range NM 88002-5502
OFF: (505)-678-4881 DSN: 258-4881 FAX: (505)-678-5104
Email:laferrir@trac.wsmr.army.mil

MS Cynthia Kee LaFreniere
Military Operations Research Society
STE 202
101 S Whiting St
Alexandria VA 22304-3416
OFF: (703)-751-7290 DSN: 484-7714 FAX: (703)-751-8171
Email:morscyn@aol.com

MS Leslie E Lampella
HQ TRADOC, DCSSA
Attn: ATAN-SM
Fort Monroe VA 23651-5143
OFF: (804)-728-5813 DSN: 680-5813 FAX: (804)-727-4394
Email:lampell@monroe.army.mil

MAJ Mark Melvin Lee
TRAC-Lee
Suite 401
401 1st Street
Fort Lee VA 23801
OFF: 804-765-1804 DSN: 539-1804 FAX: 804-765-1456
Email:leem@trac.lee.army.mil

Ms Patricia Lentini
US GAO
STE 300
5029 Corporate Woods Dr
Virginia Beach VA 23462
OFF: 757-552-8194 FAX: 757-552-8197
Email:lentinip.noro@gao.gov

Mr. Thomas C. Loncarich
US Army TRAC-WSMR
Attn: ATRC-WBB
White Sands Missile Range NM 88002-5502
OFF: 505-678-2538 DSN: 258-2538 FAX: 505-678-5104
Email:loncarit@trac.wsmr.army.mil

LtCol Lynnette M Lowrimore
AF/XOCI
1480 Air Force Pentagon
Washington DC 20330-1480
OFF: 703-588-5008 DSN: 425 FAX: 703-588-8038
Email:lynnette.lowrimore@pentagon.af.mil

MR Thomas W Lucas
NPS
Operations Research Department
Monterey CA 93943
OFF: 831-656-3039 FAX: 831-656-2595
Email:twlucas@nps.navy.mil

MR Ronald G Magee
US Army TRADOC Analysis Command
Attn: ATRC-SAA
255 Sedgwick Ave
Fort Leavenworth KS 66027-2345
OFF: (913)-684-5426 DSN: 552-5426 FAX: (913)-684-9191
Email:MAGEER@TRAC.ARMY.MIL

MR Frank C Mahncke
Joint Warfare Analysis Center
18385 Frontage Road
Dahlgren VA 22448-5500
OFF: 540-653-1872 DSN: 249-1872 FAX: 540-653-2788
Email:mahncke@aol.com

COL William E Marshall
Joint C4ISR Battle Center
STE 150
116 Lakeview Pkwy
Suffolk VA 23435
OFF: 757-686-7522 DSN: 564 FAX: 757-686-7087
Email:marshall@jbs.js.mil

Mr Douglas D Martin
Booz Allen and Hamilton
816 Greenbrier Circle
Suite 208
Chesapeake VA 23320
OFF: 757-523-4339 FAX: 757-523-4336
Email:martin_doug@bah.com

Maj Gilbert L McCauley
Canadian Forces/Director General Stategic Planning
12 CBN MGEN Pearkes Bldg
101 Col by, Ottawa, Ont CANADA K1A-0K2
OFF: 613-995-4369 FAX: 613-992-5484
Email:ac789@issc.debbs.ndhq.dnd.ca

Mr. William C McDonald
SPARTA, Inc
4901 Corporate Drive
Huntsville AL 35805
OFF: 256-837-5282 FAX: 256-830-0287
Email:mcdonaldb@huntsville.sparta.com

Dr Jimmie G. McEver III
RAND Corporation
1700 Main St
PO Box 2138
Santa Monica CA 90407
OFF: 310-393-0411 FAX: 310-451-7073

MAJ Willie J McFadden II
US Army Student Detachment
Rm. 2041
Bldg 5450
Ft. Jackson SC 29270
OFF: 757-877-6852 FAX: 757-877-6852
Email:willemcfadden@mindspring.com

MS Lana E McGlynn
ODUSA (OR)
Attn: SAUS-OR, RM 1E643
102 Army Pentagon
Washington DC 20310-0102
OFF: 703-697-0367 DSN: 227-0367 FAX: 703-697-7748
Email:mcglyla@hqda.army.mil

Mr. Larry McInnis
Atlantic Intelligence Command
7941 Blandy Road
Norfolk VA 23551-2498
OFF: 757-686-7626 FAX:
Email:mcinnis@acom.mil

Mr. Douglas A McLiverty
USACOM/J93
5248 Rolleston Dr
Virginia Beach VA 23464
OFF: 757-836-0915 DSN: 836 FAX: 757-836-0932
Email:mcliverd@erols.com

COL Michael K Mehaffey
US Army Training & Doctrine Command
Attn: ATCD-B
10 Whistler Lane
Fort Monroe VA 23651-1046
OFF: 757-727-2332 DSN: 680 FAX: 757-727-3445
Email:mehaffem@monroe.army.mi

MR Kenneth J Mellin
COLSA CORP
STE 505
1235 Jefferson Davis Hwy
Arlington VA 22209
OFF: 703-414-0940 FAX: 703-414-3683
Email:kmellin@erols.com

Mr Reed Mihaloew
MITRE Corporation
Suite 100
234 S. Fraley Blvd
Dumfries VA 22026
OFF: 703-441-7218 FAX: 703-441-1779
Email:mihaloew@mitre.org

COL James B Mitcham
HQ TRADOC
Attn: ATAN-ZA
Bldg 5G, Room 303
Ft Monroe VA 23651-1048
OFF: 757-728-5803 DSN: 680 FAX: 757-727-4394
Email:mitchamj@monroe

Mr. John J Moffatt
AC2ISRC/AFEO
STE 216
130 Andrews St
Langley AFB VA 23665-1993
OFF: 757-825-8264 DSN: 574-9945 FAX: 757-825-9945
Email:john.moffatt@langley.af.mil

CAPT Steven D Monson
OASD/C3I
6000 Defense Pentagon
Washington DC 20301-6000
OFF: 703-695-0822 DSN: 225 FAX: 703-614-7247
Email:Steven.Monson@osd.pentagon.mil

MS Kendra E Moore
Alphatech, Inc
50 Mall Road
Burlington MA 01803-4537
OFF: 781-273-3388 FAX: 781-273-9345
Email:kendra.moore@alphatech.com

MAJ Timothy S Moore
AC2TSRC/AFEO
STE 216
130 Andrews St
Langley AFB VA 23665-1993
OFF: 757-825-8234 DSN: 574-9945 FAX: 757-825-9945
Email:timothy.moore@langley.af.mil

Mr Clarence Todd Morgan
JTASC/JW940
116 Lake View Pkwy
Suffolk VA 23435-2699
OFF: 757 686-7497 FAX: 757 686-7985
Email:morgan@jwfc.acom.mil

Mr. Charles Morrisey
Directorate General Strategic Planning
101 Col By Drive, Pearkes Bldg
Ottawa, Ontario CANADA KIA-OK2
OFF: 613-996-6656 FAX: 613-992-5484
Email:ae358@issc.debbs.ndhq.dnd.ca

MAJ Robbie L Mosley
OASD (C3I)
Crystal Mall 3, 7th Floor
1431 Jefferson Davis Hwy
Arlington VA 22202
OFF: 703-607-0263 DSN: 327 FAX: 703-607-0276
Email:mosleyr@osd.pentagon.mil

MR Mark W Murray
HQ TRADOC
Attn: ATAN-A
5G North Gate Road
Fort Monroe VA 23651-5000
OFF: 757-728-5834 DSN: 680-5834 FAX: 757-727-4394
Email:murraym@monroe.army.mil

COL Steven H Myer
TRAC
255 Sedgwick Ave
Attn: ATRC
Fort Leavenworth KS 66027-2345
OFF: 913-684-6878 DSN: 552-6878 FAX: 913-684-6894
Email:myers@trac.army.mil

Mr. Donald W Neal
AFC2T1C/A7, TRW Team
138 Hartson St
Hurlburt Field FL 32544
OFF: 850-884-6837 DSN: 579 FAX: 850-884-1649
Email:neal.donald@jfacc.hurlburt.af.mil

Mr. Richard D Newton
USAF C2TIC/A5
138 Hartson St
Hurlburt Field FL 32544
OFF: 850-884-6123 DSN: 579-6271 FAX: 850-884-6181
Email:newton.rick@jfacc.hurlburt.af.mil

MS Cindy Jahnke Noble
USA TRAC
Attn: ATRC-SAA
255 Sedgwick Avenue
Fort Leavenworth KS 66027
OFF: 913-684-5511 DSN: 552-5511 FAX: 913-684-6894
Email:noblec@trac.army.mil

Dr David Noble
Evidence Based Research
Suite 250
1595 Spring Hill Road
Vienna VA 22182
OFF: 703-287-0312 FAX: 703-821-7742
Email:noble@ebrinc.com

LtCol Robert A O'Neill
ESC/DIS
Chief Modeling, Simulation & Trng Svc
5 Eglin Street
Hanscom AFB MA 01731-2116
OFF: (617)-377-8486 DSN: 478-8486 FAX: 781 377-7469
Email:oneillr@hanscom.af.mil

CAPT J D Oliver
J98-97 Assessments/Integration
96 Fenwick Road
Ft. Monroe VA 23651-5000
OFF: 757-726-6635 DSN: 680 FAX: 757-726-6181

LTC Maria Chris Pate
DCSOPS
400 Army Pentagon
Washington DC 20310-0400
OFF: 703-695-2459 DSN: 225-2459 FAX: 703-614-9044
Email:patemac@hqda.army.mil

MS Anne M Patenaude
SAIC
Suite 290
8301 Greensboro Dr
McLean VA 22102
OFF: 703-749-5109 FAX: 703-847-6406
Email:anne.m.patenaude@cpmx.saic.com

MS Lynda Pedersen
HQ USSOCOM
Attn: SOJ7-CS
7701 Tampa Point Blvd
MacDill AFB FL 33621-5323
OFF: (813)-828-7705 DSN: 968-7705 FAX: (813)-878-3880
Email:pedersl@socom.mil

MajGen Timothy Peppe
US ACOM J9
1562 Mitscher Avenue, Suite 200
Norfolk VA 23551
OFF: 757-836-6472 FAX: 757-836-6478
Email:peppe@acom.mil

Mr. Robert W Peterman
Air Force Experimentation Office
2101 Executive Drive
STE 2D, Tower box 87
Hampton VA 23666
OFF: 757-825-8234 DSN: 574-9945 FAX: 757-825-6214
Email:robert.peterman@langley.af.mil

DR Steven E Pilnick
EDO Technology Services and Analysis
West Bldg
7600 Leesburg Pike
Falls Church VA 22043-2004
OFF: (703)-714-1874 FAX: (703)-714-1801
Email:spilnick@edo-tsa.com

Mr. Alan W Plotnik
Raytheon Systems Company
STE 812
2 Eaton Street
Hampton VA 23669-4054
OFF: 757-224-0612 FAX: 757-722-6746
Email:awplotnik@west.raytheon.com

Dr Isaac R Porche III
RAND
1700 Main Street, MS 23a
PO Box 2138
Santa Monica CA 90407-2138
OFF: 310-393-0411 FAX: 310-451-7073
Email:porche@rand.org

Mr Robert J Powers
SAIC
4501 Daly Drive, Suite 400
Chantilly VA 20151-3707
OFF: 703-808-6547 FAX:
Email:Robert.J.Powers@cpmx.saic.com

Mr. Roger Pratt
SMA Corporation
901 Follin Lane
Vienna VA 22180
OFF: 703-242-4681 FAX: 703-255-3667
Email:roger.pratt@smawins.com

COL Roderick D Reay
AFOTEC/OL-VA
Suite 200 (J96)
1562 Mitscher Avenue
Norfolk VA 23551
OFF: 757-836-0721 DSN: 836-0721 FAX:
Email:reayr@afotec.af.mil

LCDR Michael L Reynolds
Atlantic Intelligence Command
STE 100
7941 Blandy Road
Norfolk VA 23551-2498
OFF: 757-836-7079 FAX: 757-836-7167
Email:reynolds@aic.ocom.mil

DR Roy E Rice
Teledyne Brown Engineering
PO Box 070007
Huntsville AL 35807-7007
OFF: 256-726-2038 FAX: 256-726-2241
Email:roy_rice@pobox.tbe.com

DR F. Russell Richards
MITRE
STE 400
7941 Blandy Road
Norfolk VA 23551-2498
OFF: 757-836-2211 FAX: 757-836-6478
Email:rrichard@mitre.org

Mr Jon A Roth
The MITRE Corporation
Suite 100
234 Fraley Blvd
Dumfries VA 22026
OFF: 703-441-1775 FAX: 703-441-1779
Email:jroth@mitre.org

Mr. Connie W Sawyer Jr
US GAO
5029 Corporate Woods Dr
Virginia Beach VA 23462
OFF: 757-552-8140 FAX: 757-552-8197
Email:sawyerc.noro@gao.gov

Mr Randall Schmidt
AC2ISRC/AFEO
2101 Executive Drive
Hampton VA 23666
OFF: 757-765-9945 DSN: 574-9945 FAX: 757-765-9945
Email:randall.schmidt@langley.af.mil

Mr. William H Schopfel
The MITRE Corporation
PO Box 8068
Camp Lejeune NC 28547-8068
OFF: 910-451-5869 FAX: 910-451-9422
Email:schopfel@mitre.org

MR Albert A Sciarretta
Quantum Research International
Suite 700
9302 Lee Hwy
Fairfax VA 22031
OFF: 703-218-2445 FAX: (703) 383-4892
Email:asciarretta@quantum-intl.com

DR Gregory Searle
Embassy of Australia
1601 Massachusetts Ave, NW
Washington DC 20036
OFF: (202)-797-3378 FAX: (202)-797-1838
Email:condsa@clark.net

Mr Daniel Serfaty
Aptima, Inc
STE 3050
600 West Cummings Park
Burlington MA 01801
OFF: 781-935-3966 FAX: 781-935-4385
Email:serfaty@aptima.com

LtCol Joseph E Sharpless
DIA
Fenwick Road, Bldg 96
Ft. Monroe VA 23651-5000
OFF: 757-726-6426 DSN: 680 FAX: 757-726-6433
Email:sharplej@jwfc.js.mil

DR Robert S Sheldon
S3I
Suite 500
1700 Diagonal Road
Alexandria VA 22314
OFF: 703-684-4529 FAX: 703-684-8272
Email:bs@s3i.com

DR David T Signori Jr
RAND Corporation
1333 H Street, NW
Washington DC 20005-4707
OFF: 202-296-5000 DSN: 426-2235 FAX: 202-296-7960
Email:signori@rand.org

Mr. Richard A Simpson (UK)
Allied Command Atlantic (SACLANT)
STE 100
7857 Blandy Road
Norfolk VA 23551-2490
OFF: 757-445-3885 DSN: 565 FAX: 757-445-3242
Email:simpson@saclant.nato.int

DR Cyrus J. Staniec
Logicon
2100 Washington Blvd
Arlington VA 22204-5706
OFF: (703)-312-3500 FAX: (703)-312-2780
Email:cstaniec@logicon.com

DR Stuart H Starr FS
The MITRE Corporation
1820 Dolley Madison Blvd #MS W557
McLean VA 22102
OFF: (703)-883-5494 FAX: (703)-883-1373
Email:starr@mitre.org

Mr. Michael D Starry
IDA
123 Sarazen Court
Newport News VA 23602
OFF: 757-836-0696 FAX: 757-836-0935
Email:mstarry@ida.org

MR Malcolm P Taylor
Pacific Sierra Research Corporation
STE 700
1400 Key Blvd
Arlington VA 22209
OFF: 703-516-6202 FAX: 703-524-2420
Email:mtaylor@psrw.com

MR Donald W Theune
Virtual Technology Corp
Suite 114
5400 Shawnee Road
Alexandria VA 22312-2300
OFF: (703)-658-7943 FAX: (703)-658-7057
Email:dtheune@virtc.com

MR Clayton J Thomas FS
AFSAA/SAN
1570 Air Force Pentagon
Washington DC 20330-1570
OFF: 703-588-6944 DSN: 425-6944 FAX: 703-588-8779
Email:Clayton.Thomas@pentagon.af.mil

Col Lynne C Thompson
HQ AF/XOCP
Alexandria VA 22312
OFF: 703-588-5010

LTC Fletcher B Thornton
The Joint Staff-J8
LLWAD
8000 Pentagon, Room 1D940
Washington DC 20318-8000
OFF: 703-695-4657 DSN: 225-4657 FAX: 703-695-8031
Email:thorntfb@js.pentagon.mil

Mr James D Touhill
Quantum Research International
Crystal Square 4, Suite 1001
1745 Jefferson Davis Hwy
Arlington VA 22202
OFF: 757-727-3551 DSN: 680-3551 FAX: 757-727-2947
Email:touhillj@monroe.army.mil

Mr. Joseph Trujillo
TRADOC Analysis Center
Attn; ATRC-WAA
White Sands Missile Range NM 88002-5502
OFF: 505-678-1558 DSN: 258 FAX: 505-678-1450
Email:trujillj@trac.wsmr.army.mil

LTC David W Tyner
Joint National Test Facility (BMDO)
730 Irwin Ave
Falcon AFB, CO 80912-7300
OFF: 719-567-8326 FAX: 719-567-9219

MR Stephen C Upton
Los Alamos National Lab
TSA 5, MS F602
PO Box 1663
Los Alamos NM 87544
OFF: (505)-667-9435 FAX: (505)-665-2017
Email:upton@lanl.gov

MS Gwendolyn D Vantree
HQ TRADOC, DCSSA
ATTN: ATAN-SM
Bldg 5G, 3rd Floor
Ft Monroe VA 23651-1048
OFF: 757-728-5833 DSN: 680-5833 FAX: 757-751-4394
Email:vantree@monroe.army.mil

Mr. Charles D Vollmer
Booz Allen & Hamilton
OFF: 703-902-5541 FAX: 703-902-3374

MR Charles E Walters
OSD JTE&E Program Office
STE 800
2001 N Beauregard St
Alexandria VA 22311
OFF: 703-578-6122 FAX: 703-578-6172

Ms. Delores Washburn
Space and Naval Warfare System Command
PMW132
4301 Pacific Hwy
San Diego CA 92110-3127
OFF: 619-537-0194 FAX: 619-537-0155
Email:delores@spawar.navy.mil

Ms Linda L. Weber
USACOM J97/MITRE
Atlantic Intelligence Command
7941 Blandy Road, Suite 400
Norfolk VA 23551-2498
OFF: 757-726-6161 DSN: 680-6161 FAX: 757-726-6181
Email:weberl@jwfc.js.mil

RADM Gary F Wheatley (USN-Ret)
Evidence Based Research, Inc
STE 250
1595 Spring Hill Rd
Vienna VA 22182-2228
OFF: 703-893-6800 FAX: 703-821-7742
Email:wheatley@ebrinc.com

MR Richard I Wiles
Military Operations Research Society
101 S Whiting St #202
Alexandria VA 22304
OFF: (703)-751-7290 FAX: (703)-751-8171
Email:morsone@aol.com

CAPT Richard B Williams
SPAWARSYSCOM
PMW132 (C60/317)
4301 Pacific Hwy
San Diego CA 92110-3127
OFF: 619-537-0197 DSN: 577 FAX: 619-537-0153
Email:willrb@spawar.navy.mil

MS Lauran Winter
HQ TRADOC
ODCSSA
ATTN: ATAN-SM
Fort Monroe VA 23651-5143
OFF: DSN: 680-5953 FAX: 717-245-3603
Email:winterl@awc.carlisle.army.mil

Mr. Dale R Winzer
AC2ISRC/AFEO
STE 216
130 Andrews St
Langley AFB VA 23665-1993
OFF: 757-825-8234 DSN: 574-9945 FAX: 757-825-9945
Email:dale.winzer@langley.af.mil

LTC Mark S Woempner
TRAC-WSMR
Bldg 1400
White Sands Missile Range NM 88002
OFF: 505-678-2956 DSN: 258 FAX: 505-678-1450
Email:woempnem@trac.wsmr.army.mil

DR D. Robert Worley
IDA/CSED
1801 N Beauregard Street
Alexandria VA 22311
OFF: (703)-845-6631 FAX: (703)-845-6848
Email:rworleyda.org

MR Michael E Wright
The MITRE Corporation
MS 1302
202 Burlington Road
Bedford MA 01730
OFF: 781-377-8505 FAX: 781 377-7469
Email:mewright@mitre.org

MS Susan J Wright
Institute for Defense Analyses
1801 N. Beauregard Street
Alexandria VA 22311-1772
OFF: 703-845-6628 FAX: 703-845-6809
Email:sjwright@ida.org

Maj Chris Yunker
Office of Naval Research
800 N Quincy Street
Arlington VA 22217-5660
OFF: 703-696-7020 DSN: 426-7020 FAX: 703-696-4162
Email:yunderc@onr.nary.mil

Ms. Anita A Zabek
The MITRE Corporation
1820 Dolley Madison Blvd
McLean VA 22102
OFF: 703-883-1389 FAX: 703-883-6435
Email:aradams@mitre.org

LtCol Frank A Zawada
AFRL/VSSW
29 Randolph Road
Hanscom AFB MA 01731-3010
OFF: 781)-377-8004 DSN: 478-8004 FAX: 781)-478-5640
Email:zawada@plh.af.mil

Mr. Steven R. Zeswitz
The MITRE Corporation
PO Box 8068
Camp Lejeune NC 28547
OFF: 910-451-5869 DSN: 751-5869 FAX: 910-451-9422
Email:zeswitz@mitre.org